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VOLUME VI

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ELECTRONICS HANDBOOK

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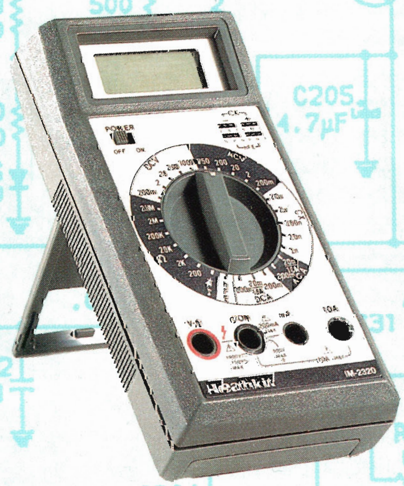

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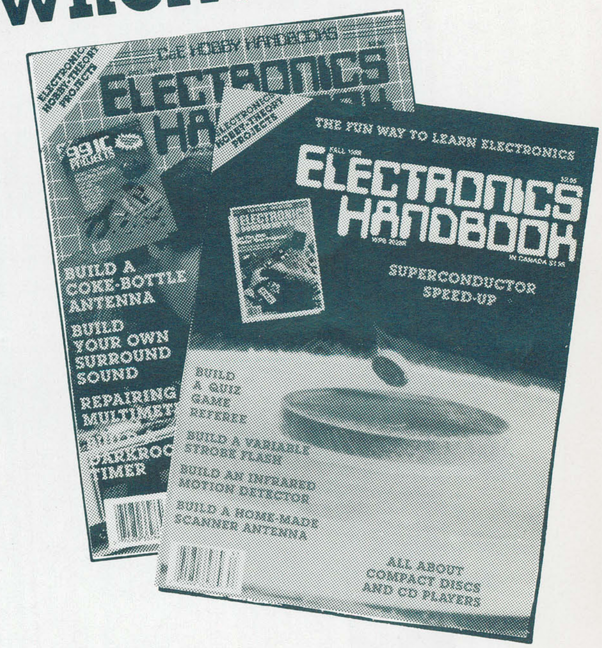

In case you're not all that familiar with us, we're not a publication for electrical engineers and other wizards. No way, ELECTRONICS HANDBOOK is expressly for people who like to build their own projects and gadgets—and maybe get a little knee-deep in tape, solder and wire clippings in the process.

In fact, we have a sneaking suspicion that our readers like us because they think we're just as bug-eyed and downright crazy over great new project ideas as they are. And I guess they're right!

ELECTRONICS HANDBOOK thinks of you who dig electronics as the last of a special breed. It's more than just the "do-it-yourself" angle—it's also the spirit of adventure. In this pre-packaged, deodorized world, building your own stereo system, shortwave receiver, darkroom timer or CB outfit is like constructing a fine-tuned little universe all your own. And when it all works perfectly—it really takes you to another world.

ELECTRONICS HANDBOOK knows the kinds of projects you like—and we bring 'em to you by the truckload!

Ever hanker to build a sharp-looking digital clock radio? Or to hook up an electronic game to your TV? Or an easy-to-build photometer that makes perfect picture enlargements? Or a space-age Lite-Com so you and the family can talk to each other on a light beam? We've got it all to get you started.

Has your sound system gone blooey just when the party's going great? Do you shudder when your friendly neighborhood electrician hands you the bill? ELECTRONICS HANDBOOK can help.

Of course, we can't make you a master electrician overnight. But we can show you the fundamentals of repair plus maintenance tips.

IF YOU'RE NEW TO ELECTRONICS YOU GET A "BASIC COURSE"!

It gives you a complete, ground-floor lowdown on a variety of important electronic subjects. For example—Understanding Transistors...How Radio Receivers Pull in Signals...Cathode Ray Tubes Explained...How Capacitors Work...Using Magnetism in Electronics, and much, much more!

TRY A FEW ISSUES AND EVALUATE OUR...

- **HOW-TO-DO-IT HELP** Tips and pointers that add up to money saved. For example—tuning up your tape player...all about radios ...whys and hows of turntables...care and feeding of speakers.
- **EXCITING DISCOVERIES.** Whatever your particular interest in electronics, you'll be entering a world of discovery in the pages of the ELECTRONICS HANDBOOK

No other training—in school, on the job, anywhere—shows you how to trouble-shoot and service computers like NRI

HARD DISK
20 megabyte hard disk drive you install internally for greater data storage capacity and data access speed.

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NEC V40 dual speed (4.77 MHz/8 MHz) CPU, 512K RAM, 360K double-sided disk drive.

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Only NRI walks you through the step-by-step assembly of a powerful XT-compatible computer system you keep—giving you the hands-on experience you need to work with, troubleshoot, and service all of today's most widely used computer systems. You get all it takes to start a money-making career, even a business of your own in computer service.

No doubt about it: The best way to learn to service computers is to actually *build* a state-of-the-art computer from the keyboard on up. As you put the machine together, performing key tests and demonstrations at each stage of assembly, you see for yourself how each part of it works, what can go wrong, and how you can fix it.

Only NRI—the leader in career-building, at-home electronics training for 75 years—gives you such practical, real-world computer servicing experience. Indeed, no other training—in school, on the job, *anywhere*— shows you how to trouble-shoot and service computers like NRI.

You get in-demand computer servicing skills as you train with your own XT-compatible system—now with 20 meg hard drive

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Only NRI gives you a top-rated micro with complete training built into the assembly process

Your NRI hands-on training continues as you install the powerful 20 megabyte hard disk drive—today's most wanted computer peripheral—included in your course to dramatically increase your computer's storage capacity while giving you lightning-quick data access.

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In no time at all, you have the confidence and the know-how to work with, troubleshoot, and service every computer on the market today. Indeed you have what it takes to step into a full-time, money-making career as an industry technician, even start a computer service business of your own.

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You need no previous experience in computers or electronics to succeed with NRI. You start with the basics, following easy-to-read instructions and diagrams, quickly moving from the fundamentals to sophisticated computer servicing techniques. Step by easy step, you get the kind of practical hands-on experience that makes you uniquely prepared to take advantage of every opportunity in today's top-growth field of computer service.

What's more—you learn at your own pace in your own home. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move. And all throughout your training, you have the full support of your personal NRI instructor and the NRI technical staff always ready to answer your questions and give you help whenever you need it.

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Send today for your free full-color catalog describing every aspect of NRI's innovative computer training, as well as hands-on training in robotics, video/audio servicing, electronic music technology, security electronics, data communications, and other growing high-tech career fields.

If the coupon is missing, write to NRI School of Electronics, McGraw-Hill Continuing Education Center, 4401 Connecticut Avenue, Washington, DC 20008.

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ELECTRONICS HANDBOOK

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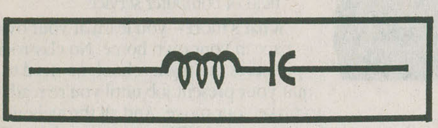

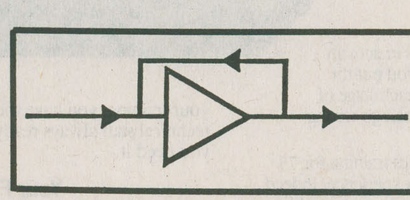

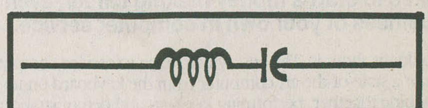

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RF Noise Generator ...
Solar Battery Charger ...

REORGANIZATION TIME

Readers of the ELECTRONICS HANDBOOK will observe, those who are interested, that we have made several changes in our staff since the last issue. The vagaries of publishing have dictated that we make these changes in our modus operandi.

The world of electronics is daily becoming more challenging. Technology is becoming more specialized, and the importance of electronics in our lives increases every day. Test instruments, home appliances and entertainment, automobiles and industrial control systems rely more and more on electronics.

The ELECTRONICS HANDBOOK will continue to provide the readers with fundamental background in electronic systems, principles and applications..how various circuit designs accomplish different purposes. Much of this will be accomplished by hands-on, do-it-yourself projects. Step-by-step, you can learn how and why electronics has become a part of our everyday world and the even bigger role it will play in the future.

While the "Handbook" seems to have been generally accepted by readers for what it has endeavored to be...a magazine for Electronics Hobbyists and Project Builders, we have obviously failed to maintain a regular schedule of publication, therefore, effective with this current issue, we will revert to a "series" frequency of publication with each issue following a numerical sequence. Thus, we start with "Volume #6" (current issue), since we have published five previous issues.

To be quite candid, this takes much of the deadline pressure off the publisher and the staff. We will endeavor to publish at least two, hopefully three or four, issues each year and we truly hope that you will be watching for us at your favorite newsstand.

A few observations about this issue. You will recognize some of our familiar contributing authors: Ed Noll, Walt Sikonowiz, Homer Davidson and Glenn Rawlings and some new contributors, who have joined our staff and, we are confident, will be with us for future issues. We think that we now have a winning combination of authors and editorial expertise to make the ELECTRONICS HANDBOOK the magazine you want it to be...for the Hobbyist and the Project Builder.

Don Gabree

Don Gabree, *—Publisher*

WANTED: PROJECTS

How would you like to find your home-brew project in the next issue of the ELECTRONICS HANDBOOK? It's up to you! Build your project for yourself....It should have a real purpose. Then, if you think it is good enough to appear in the ELECTRONICS HANDBOOK, letusknow about it.

Write us a short letter describing your project. Tell us what the project does. Provide us with a legible schematic diagram and a few black-and-white photographs of the project...photos are important. After we have read your letter, we'll let you know, one way or the other, whether we would like to purchase your article describing the project. Send your letter to:

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FROM THE EDITOR'S DESK

Ask The Editor, He Knows!

Got a question or a problem with a project—ask The Editor. Please remember that The Editors' column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:

The Editor
C&E HOBBY HANDBOOKS INC.
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Liquid Nitrogen

In the last issue of **Electronics Handbook** you explained superconductivity, and told how to demonstrate the Meissner effect, which levitates a magnet over a superconducting disc. Although you had some suggestions on where to obtain liquid nitrogen, which is used to supercool materials, I haven't been able to get hold of the liquid nitrogen. I need to supercool materials in demonstrating superconductivity. Do you have any further suggestions for those of us who would like to set up this fascinating demonstration? How much does liquid nitrogen usually cost?

—Shawn Osmond, Duluth, MN.

You can more easily find liquid nitrogen near large cities, where there are more hospitals, commercial welding shops, and suppliers of liquified gases, including helium and oxygen. However, rural areas are more likely to have farms with facilities for artificially inseminating horses or cattle. They need liquid nitrogen to preserve the stock until needed. And if a small welding shop can't help you, some doctors, especially podiatrists, as well as physics labs in colleges, should be able to help.

The price of liquid nitrogen may vary from two dollars a liter up to four times that much.

As noted in our supercon story, you have to carry and store liquid nitrogen in a highly-insulated (but definitely not sealed) container. For brief periods, an ordinary Thermos (unsealed) bottle will do. For longer periods you need a Dewar (a Thermos is a form of Dewar). Commercially-available Dewars for handling liquid gases can be rented for a few days, which is the way to go if you've got several people working together such as a science class. But be very careful in handling any liquid gas. The extremely low temperatures can cause injury if contacted directly.

In addition to the soupercon materials available from Edmund Scientific (Barrington, NJ 08007) which were described in the article in our previous issue, The Heath Company of Benton Harbor, Michigan 49022 has supercon pellets etc. needed to perform the Meissner-effect levitation demonstration. You can get the Edmund and Heath catalogs by sending a postcard request.

Converting Foreign Tapes

I have a programme taped in India, using PAL system camera and VHS tape. When I try to play the tape here, I get the sound and not the picture. I was told that the VCRs here are made to play only those tapes recorded with NTSC system cameras. Is there any way to convert my tape to play in VCRs with NTSC system? Is there any device available for conversion?

As I am an electronics hobbyist, I can assemble any device to convert the tape from PAL system to NTSC system.

N. Mohan, Nashville, TN 37208

Unfortunately, there's no easy way you can readily convert video tapes made overseas, using PAL system, to what we use here in the U.S. (NTSC system). The reason you can hear the sound is that audio signals are laid down in a straight line on the edge of the tape, very much like audio signals on a cassette or reel-to-reel tape. The video tracks, synchronized with the video lines of each field, must be played back with a rotary scanning head, using the different frequencies employed in PAL.

It can be done, but only with very complicated and very expensive equipment.

Blowing Out Tubes And Transistors

I know that you can burn out a power transistor (output stage) if you short the output. But I've also been told by old timers that you will blow the power output tubes and/or the output transformers by running a tube set *without* a load (speaker) hooked up. Is there anything to this, or is it one of the many stories old radio men use to scare the uninitiated.

—Benjamin Montrose, Durham, NC.

These two situations illustrate some of the differences between vacuum-tube and transistor circuitry. Operating a transistor power stage with too small a load-a very small resistance, such as a direct short across the output-can indeed, almost certainly would, burn out the power output transistor because it would try to supply a very high output current to that load.

On the other hand, operating a vacuum-tube output with no load connected, might burn it out. Here's why. With no load on the secondary of the output transformer, the primary of the transformer which is connected from the plate of the tube to ground, would act like a very high impedance to the tube's output. Thus the voltages across the primary (plate to ground) could

easily rise high enough to arc across the tube elements and/or the transformer. You might get a breakdown in the insulation between the windings of the output transformer or burn out the tube.

Whether that actually happens or not depends on how hard the tube's grid is driven-if strong enough signals are input to the grid to drive the output (plate) hard enough.

I heard that story many times back when I used to work on tube equipment, yet I never burned out any tubes or transformers. But that's probably because I never put any strong signals into the input of an unloaded power stage.

Of course one would never purposely short the output of a transistor stage on purpose, any more than you would connect a piece of wire across the output of any other generator or power source, be it an AC power supply, a car battery, or just a flashlight battery. Any source of power trying to supply an infinite amount of current to a very small load (nearly zero resistance) would burn itself out fast.

20's Radio Brings Back Memories

I enjoyed your article on the 20's radio kits. I don't go quite that far back but my first radios were built around galena detectors and 01A tubes. I still have a good supply of both and, no, they aren't for sale! Your article brought back memories of long-ago nights when, as a boy, I sneaked out of bed at 2:00 AM to DX on a one or two-tuber! During the early years of WW II, I listened to Tokyo Rose on a Two-tube super regenerator that used a 30 and a 33. It used an 8" antenna and was so hot with RF that I had to use an 18" wooden dowel for a turning shaft.

I have a crystal set I put together a few years back that uses the antenna coupling variometer from a surplus broadcast band transmitter. When I lived in San Jose, Calif. I could receive most of the San Francisco stations strongly enough to operate the magnetic loudspeaker from an old RCA (Circa 1928).

—Billy R. Pogue, Lake Havaus, Arizona

Thanks for your interesting letter Billy. It brought back some memories of early radio of our own, including listening to early crystal sets and one-tube sets under the covers after "lights-out" time.

Indoor FM Antennas

Every so often I see an indoor FM antenna advertised "as good as" (or sometimes "better than") outdoor antennas. Have the laws of electromagnetic propagation been suspended? Is it ever possible to get pictures or sound as well or better, a small indoor antenna as with a real (outdoor) antenna?

—James L. Stern, Francisco, CA.

No Jim, the basic physical laws governing transmission of radio waves haven't changed. Only the rules governing fast-buck manufacturers and their advertising copywriters.

Compact indoor FM antennas, whether in a box, or a vertical less than a yard high, are sometimes useful in an apartment or other cramped-for-space situation. A rabbit-ears TV antenna can often provide useful sound or pictures. But if you can't orient an antenna or get it up high enough, there's no way it can come anywhere near the results you'd get from a simple wire dipole aimed broadside to the station, particularly if you get it up high.

Like the man says, you don't get nuttin' for nuttin', nohow.

Needs Help!

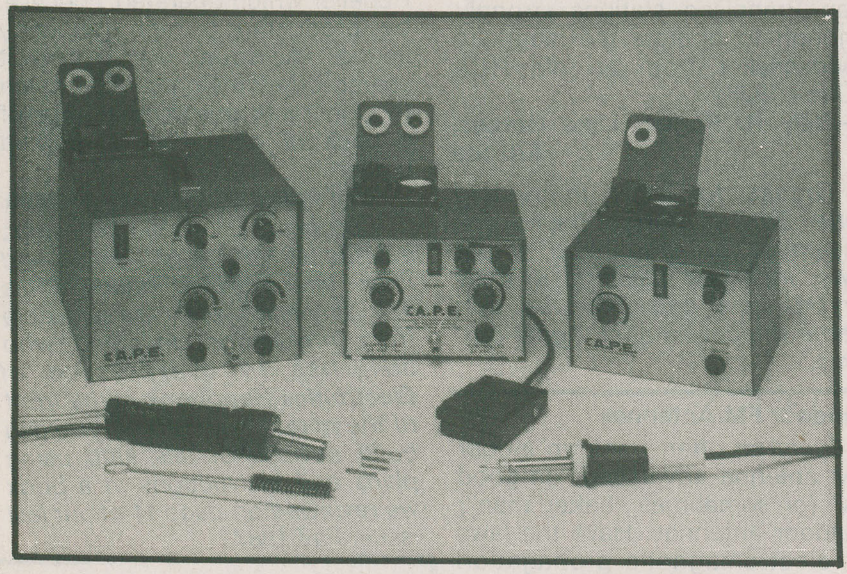
Congratulations on your excellent magazine. As an avid fan, I look forward to every issue. I hope you can help me locate a gadget I came across while visiting the US several years ago. It was a portable, battery-operated Dog Repeller which operated, I believe, by producing a high-frequency sound. The sound was so high it scared off attacking canines, even though it was only about the size of a pack of cigarettes. It worked brilliantly.

—Len Fidler, Clayfield, Australia.

It probably produced ultrasonic sounds at very high levels, and likely also warbled rapidly. This and similar devices are available from Information Unlimited, who advertise in every issue of ***Electronics Handbook*** *at the front of the magazine. Further, you can build devices of this kind using plans and instructions in a book we reviewed on page 11 of our last issue, Fall 1987.*

NEW PRODUCTS PARADE

PORTABLE, BENCH-TOP SOLDER EXTRACTION SYSTEMS

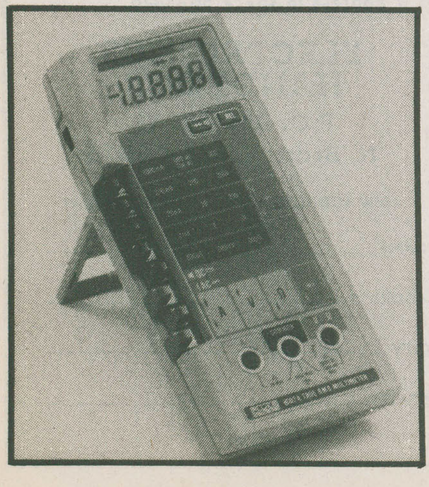


Automated Production Equipment Corporation offers three new generation models of their bench-top desoldering systems, EX-500, EX-501 and EX-525, which they appropriately identify as "self-contained, portable, bench-top solder extraction systems" with the following new features:

1. Zero voltage switching and localized grounding for CMOS safety.
2. Finger switch/Foot switch option for precise operators control.
3. Low voltage heating elements and accessories for operators safety.
4. Microprocessor controlled temperature regulation.
5. Self-contained pumps that produce the highest vacuum force of 18-26 Hg.

A.P.E. also offers free literature describing the features and benefits of their "stations" for full repair capabilities of any electronic assembly.

Call or write: **Automated Production Equipment Corporation, 142 Peconic Avenue, Medford, N.Y. 11763, (516) 654-1197.**



FLUKE'S NEW DIGITAL DMM

Finally—a digital multimeter that has frequency measurement as part of the package. Frequency ranges on the Fluke 8060A go as high as 200KHz with an extended range to 700KHz...all autoranged. For the electronics serviceman, it eliminates the necessity of carrying several meters around on service calls. It measures AC or dc voltages in dB, dBm, or relative dB for simplified amplifier gain tests, in addition to the usual complement of AC and dc voltage and current ranges, resistance and conductance ranges and continuity and diode test functions and the manufacturer claims the 8060A to be accurate to within 0.04% dcv.

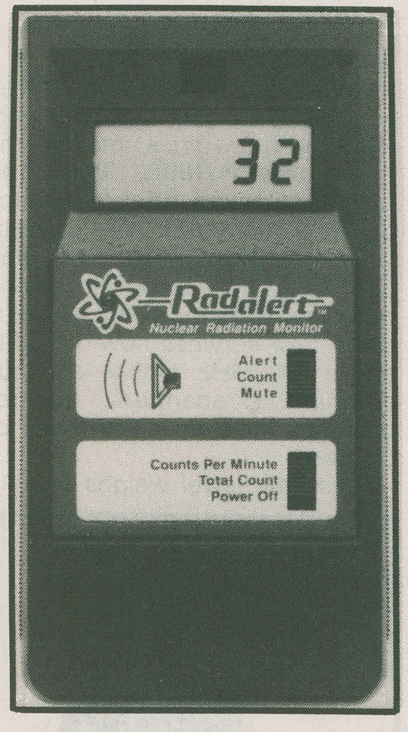
For those times when you need to check changes in value against a particular measured value, Fluke has a model 8062A, with relative reference...relative or offset measurements in any function displayed as + or − changes from a stored value. The 8062A will remember your stored value and function...even if you change ranges! The 8062A is overload-protected up to 1000vdc, 750VAC, and 500v in resistance mode and the current ranges are fused. The 8062A not only tells you what's wrong in your circuitry, it also lets you know when there is something wrong in its own circuitry. This hand-held Fluke DMM has an accuracy factor of 0.05%. It operates on a 9V battery (170 hours) and weighs less one pound.

For further information, contact **EIL INSTRUMENTS, INC., 10 Loveton Circle, Sparks, MD. 21152-9989 or call; 1-800-345-4678 (Maryland 301-771-4800, Canada 1-800-387-3344).**

RADALERT

The Radalert is a hand-held nuclear radiation monitor that detects Alpha, Beta, Gamma and X-radiation. Its user-adjustable alarm, digital readout, and computer output make it unique among low-cost radiation detectors. It measures radiation in individual counts, ionizing events in the Geiger-Mueller tube. You can switch the LCD display to either counts per minute or accumulated counts. Conversion factors for mr/hr are provided. The Radalert also features a user-adjustable audible alert and computer interface capability for recording radiation levels and working with the data.

The Radalert can measure radiation from a wide variety of



isotopes. You can use such household and evironmental items as ceramicware with uranium oxide glazes, old radium dial clocks and watches, gas camping lantern mantles, and rock collections as demonstration sources.

The Radalert is available fully assembled and tested or as a kit that you can assemble yourself. The kit comes with complete assembly instructions and is recommended for experienced electronic kit builders. It runs on one nine-volt battery and has a three to six month battery life with continuous use at normal background levels. The assembled Radalert is available for $275.00 and the kit for $185.00 from **International Medcom, 7497 Kennedy Rd., Sebastopol, CA 95472 (707) 823-0336.** Free brochure available on request.

TOSHIBA QUADRANT TVS & VCRs

Toshiba has been in the forefront of displaying two pictures on one screen (Picture-in-a-Picture), with a smaller second picture from a second channel displayed in the corner of the main picture from channel One. They call this Quadrant Effect. In their latest version of the Quadrant Effect, Toshiba uses memory storage IC chips to store the pictures. This allows the TV screen to freeze any of four pictures (or all) for further examination. Pictures from any channel can be stored (as the main picture), or as one, two, three or four corner pictures.

In addition one or more pictures from a TV program or tape can be stored in sequence from one (or more) program sources, for simultaneous display. And of course two to four TV channels (or other program sources) can be shown at the same time on one screen. Finally, one can set the Quadrant Effect to step from one frame to the next, in sequence, as multi-screen slow-scan (freeze-frame slow advance).

Numerous other combinations of freeze-frame, slow-scan, and frame advance can be programmed using the four-quadrant picture-in-a-picture system.

Toshiba's CVR DX-7 includes digital memory ICs for mass memory which permit many effects similar to those described above for Toshiba TV screens. These VCRs also feature slow-motion, double-speed and other special effects which can combine with picture-in-a-picture (Quadrant Effect).

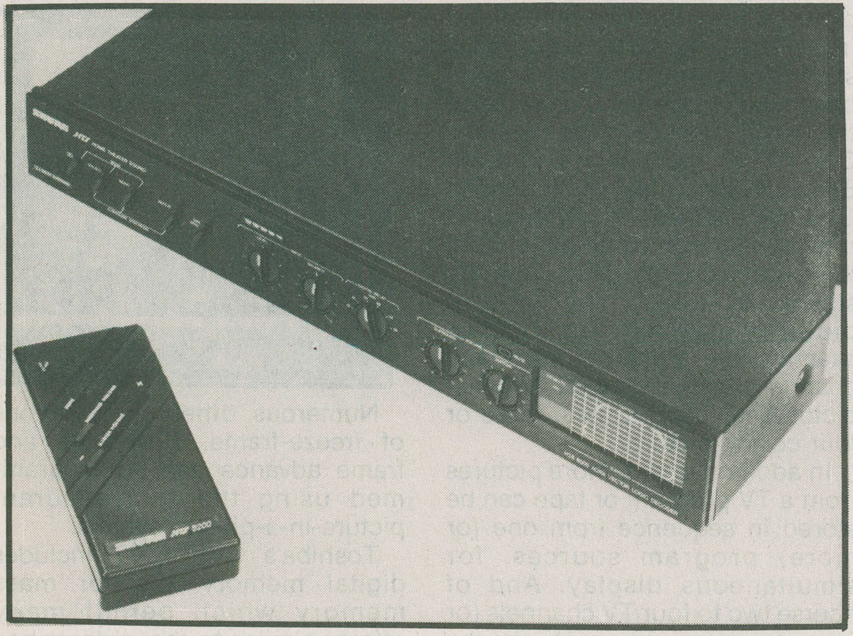
YAMAHA DUAL-DECK CASSETTE MACHINES

There are numerous dual-deck cassette recorders now available for ready duplicating of cassette tapes. Yamaha has been supplying many of them, and their two latest models include many new features at lower-than-previous prices.

The KX-W302U has auto-reverse in both Record and Playback on deck A, and deck B reverses automatically during Playback. This model includes not only Dolby B and Dolby C noise reduction, but also Dolby HX Pro dynamic bass servo for extended headroom. It also optimizes bias and tape equalization for any tape inserted into the deck, a *record return* mode to automatically rewind the tape to the beginning of a recording, and *music search* which rapidly seeks the next selection on a tape. This model can also be controlled via infra-red remote (Yamaha's model RS-KW5). It's priced at $449.

The firm's similar model KX-W202U includes most of the higher-priced units features, except the remote-control capability and is priced at $349 at all Yamaha dealers. Write **Yamaha Electronics at 6660 Orangethorpe Avenue, Buena Park, CA 90620.**

NEW PRODUCTS PARADE



HOME THEATER SURROUND SOUND DECODER

Shure Brothers, Inc., world's leading manufacturer of phono pickups, has released a Surround Sound decoder which produces multi-channel sound (up to six channels) from the Dolby sound track information contained in most new movies, such as Miami Vice, Indiana Jones, Return of the Jedi, Rocky IV, Beverly Hills Cop, Poltergeist II, Amadeus, Chariots of Fire, The Empire Strikes Back, Raiders of the Lost Ark and more than 1500 other recent hit movies.

The 5200 is an improved version of Shure's ground-breaking model 5000 decoder which provided Dolby surround sound to home systems with the addition of just two speakers and one amplifier to the usual home stereo system. For complete Dolby sound, just as in movie theaters, the new system also adds a center channel speaker and subwoofer. Available at most audio salons and from **Shure Bros, Inc., 222 Hartrey Avenue, Evanston, IL 60202. Telephone 312-866-2200.**

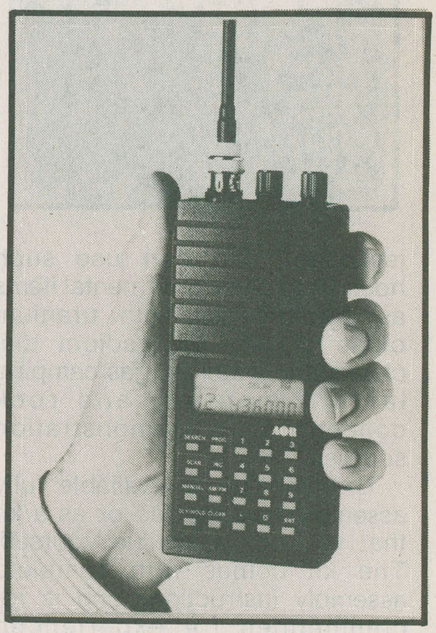
PORTABLE CD PLAYER ADDS FM-AM

Toshiba's portable CD player XR-9737 has stereo digital synthesized tuning with a liquid crystal display and clock. In addition to a three-beam laser pickup it features 16-program random memory selection with repeat, a choice of up to 14 preset radio stations, and rechargeable NiCAD battery operation. A phone jack is included for connecting headphones or to use the XR-9437 with a home components system. Contact your high fidelity dealer or **Toshiba at 83 Totowa Road, Wayne, NJ 07470 or phone 201-628-8000.**

WIDE RANGE SCANNING RECEIVERS

AOR, Ltd. announces three wide-range scanning receivers featuring the world's smallest, the hand-held AR800. This tiny scanner covers the frequency bands 30-50 MHz, 118-136 MHz, 140-174 MHz, 436-512 MHz, and 830 to 950 MHz—all police, fire and other emergency services, plus some new services now available above 800 MHz. Unlike previous comparable scanners, no frequencies have been restricted or omitted.

This little jewel weighs only 19



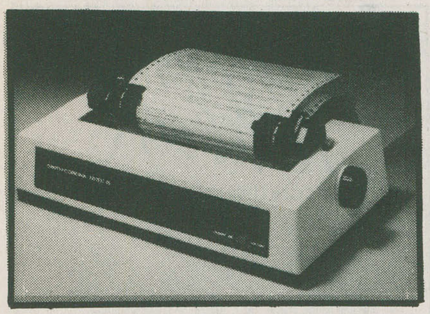
ounces, and is a minuscule 5-inches high, 1.7 inches deep and only two and one-quarter inches wide. Its control panel has 20 keys for accessing the onboard microcomputer which synthesizes the desired frequency and displays it on the sidelighted liquid crystal display. The AR800, including rechargeable battery and battery charger, lists for $299.

AORs two other scanning receivers include the AR2002, which covers up to 1.3 Gigahertz in two bands—25 through 650 MHz and 800 MHz through 1300 MHz (1.3 GHz). The AR2002 adds to the

features of the AR800, a signal-strength meter, selectable scanning speed, delay, mode and search-increment selection. In addition this desktop model has keyboard lockout, antenna, AC adaptor and DC power cord.

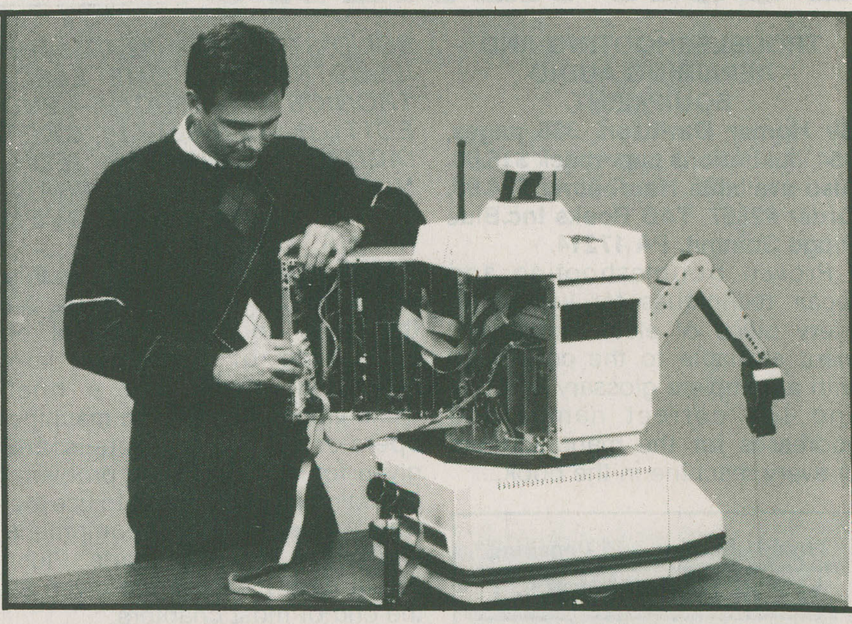
The AR160 is designed for mobile (car) use. It covers the ranges 29-52 MHz, 136-174 MHz, and 436-512 MHz, and weighs a mere 25 ounces. For price, availability and name of nearest dealer, contact **Ace Communications at 10707 East 106th St., Indianapolis, IN 46256, or call toll-free 1-800-445-7717.**

LOW-COST PRINTER



Smith-Corona Inc., world's largest maker of electric typewriters and printers, is offering a new low-cost computer printer, the Fastext-80. This dot-matrix machine has the standard Centronics (parallel) interface, so it can be connected directly to most small computers. It features bi-directional printing, friction paper feeding, and true descenders on letters, such as f, p and g.

The Fastext-80 prints at 80 cps (characters-per-second) and 10 lines-per-inch. It uses an easy to replace (drop-in) ribbon cassette which is guaranteed to produce at least a million characters before needing to be replaced. Substantial discounts, at most office supply and typerwriter stores, are generally available off the SCM list price of $259. For additional information, contact **Smith-Corona, 65 Locust Avenue, New Canaan, CT 06840; (203) 972-1471.**



HERO 2000 AUTOMATION & ROBOT ARM TRAINERS

The Heath Company has added a Robot Arm trainer to its Hero 2000, the most advanced robot you can build, while learning about robotics. The new robot arm trainer provides training and robot arm capability at lower cost than the Hero 2000, which is mobile. Since most robot applications don't require the mobile function, the new robot arm trainer simulates the operation of full-scale robots at lower cost and without the unnecessary complexity of earlier mobile robots, such as Hero(s).

Heath is known the world over as the leading manufacturer of kits, components and electronics training aids, and is now celebrating its 40th year as the leading such manufacturer. Their free catalog has over one hundred pages of kits and electronic instruments. Personal help is always available via the telephone, and you can order toll-free from **Heath at 1-800-253-0570,** or write to the address below.

To get the details on Hero, robot arm training courses and robotics components as well as the largest selection of kits, instruments and other electronic components, telephone, or write to the **Heath Company in Benton Harbor, Michigan 49022.**

MAMMOTH ROM DISK STORAGE ADD-ON FOR PCS

SONY Corp. has joined the ranks of advanced storage manufacturers with its CDU-6100 stand-alone CD-ROM optical disk storage-drive (similar to audio CDs), which can be added to IBM PCs, PC-XTs, ATs and many clone systems. The unit includes a PC interface (Sony bus) connecting cable, disk caddy (see the photo) and MS-DOS CD-ROM extension.

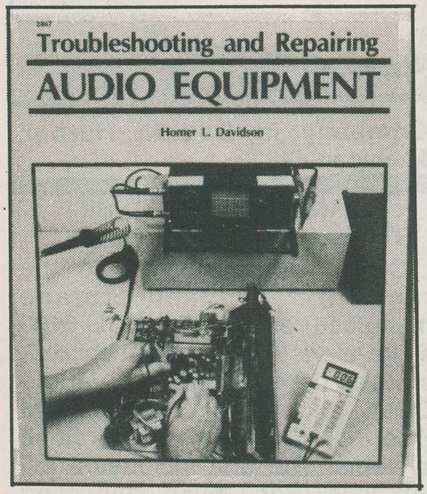
The system provides up to 540 Megabytes (!!) of data storage as well as sound (audio) CDs (music). This compares with conventional hard disks now available in PC systems of 20, 40 and up to 80 Megabytes on hard disks. Price $1,000, including interface cord & cable. **Sony Corp. of America, New York, NY 10019 and River Oaks Parkway, San Jose, CA 95134.**

NEW BOOK REVIEWS

TROUBLESHOOTING AND REPAIRING AUDIO EQUIPMENT

By Homer Davidson, 336 pages, 354 illustrations paperback $16.60. Also available Hardbound $24.95. Order #2867, TAB Books Inc.Blue Ridge Summit, PA 17214.

Proven troubleshooting and repair techniques for just about every piece of electronic equipment available to the consumer, with a complete glossary of terms and the correct names and addresses for the manufacturers of every machine in the book....



Homer Davidson has done it again. Here are all the insider's secrets to repairing tape decks, compact disk players, car stereos, telephone answering machines, portable stereos, and many other common entertainment devices. With his nearly four decades in the business of electronic repair, Davidson has seen just about every problem that a tape player or stereo can have.

Before opening his own radio and television repair shop in 1946, Homer Davidson worked in electronics for the Civil Service and was a radar instructor with the U.S. Air Force, He is the author of more than 800 articles for 47 different magazines and 15 other books for TAB. A few of his successful books include *TROUBLESHOOTING AND REPAIRING SOLID-STATE TVs* (#2707), *THE ILLUSTRATED HOME ELECTRONICS FIX-IT BOOK—2ND EDITION* (#2883), *POCKET DIGITAL MULTIMETER TECHNIQUES* (#1887), *and PRACTICAL MICROWAVE OVEN REPAIR* (#1667).

Now, in this book, he shares this wealth of information with us. All the most common ailments of each type of equipment are described, along with a brief explanation of how each machine operates. Complete details are given for repairing each problem, including how and when to use the various pieces of test equipment and where to locate parts. Plus, actual case histories are given at the end of most chapters.

Electronics hobbyists, stereo enthusiasts, and even professional repair people will find this book to be an indispensable reference. With Homer Davidson's sound advice and techniques, every reader will be able to save time and money by doing repairs at home.

Electronic Notebook: Using Your Micro To Get Better Grades

P.G. Springer
168 pages, paper, $9.95
Dilithium. Beaverton, OR. 97005

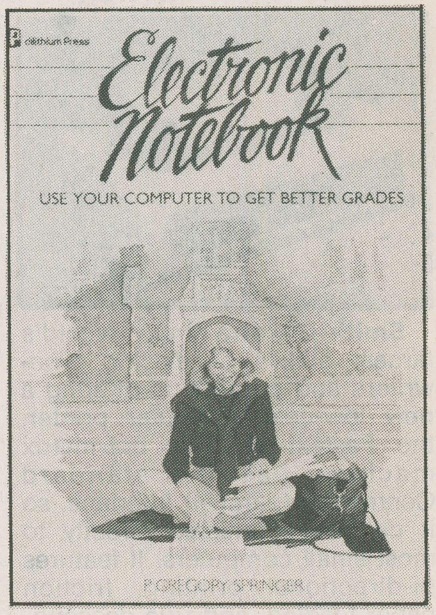
This book is for high school and college students, and tells how to use a micro to learn school subjects faster and better. It gives an amazing number of ways to use micros, and it does so without requiring any programming, or referring to any special brand or model of micro.

Electronic Notebook describes ways to take notes with a micro, getting ready for tests, accessing information, finding free programs, organizing your life (as well as your studies), storing information, indexing files, and many other things you probably never dreamed of before.

Springer points out that two or three programs, maybe only one, can cut anyone's (student) workload in half. "Computers were developed to simplify your life, not complicate it.

"Used properly...your micro can make study easier than was dreamed in the days of the one-room schoolhouse. Once a plan of action (several are detailed) is under way, studying with a micro is speedy and continually surprising. The shock of the horseless carriage was minor by comparison.

"After you understand certain ideas (carefully explained) computers are no more frustrating to use than dishwashers. In fact, most people end up loving their micro and it's hard to stop exploring its (and their own) possibilities."



Choosing Is Tough

The author claims, and I agree, "The most difficult thing about computers is choosing one. What comes after that may be frustrating at times, but more often it's enthralling and enjoyable...How to decide?...The answer is simple: Act with great diligence and caution (hard work and care) in choosing, and buy only after personally testing the micro."

He continues, "Sometimes circumstances will relieve you of this choice." More colleges and universities are adopting one brand of

micro or another. Many get Apple Macintoshes at a discount; Dallas Baptist College requires all incoming students to have a Tandy 100 (available at a discount through the college); and Carnegie-Mellon (Pittsburgh) will have all students computerized by 1986 with especially-built IBMs.

Two Iron Commands

Springer lays down two commands for students who follow his advice using a micro in school. One is, "You must USE the computer. Make it work for you..." The second is "Learn to type. If you passed up the chance to learn earlier, it's not too late. You must learn to type faster than you can write, and to do it without looking at the keyboard."

Forget Programming

He tells you to learn all you can about your micro, but at a reasonable pace. And more important than any of the above is his (correct) statement "There are plenty of good reasons *not to learn programming.* For some reason there's widespread assumption that one must know... programming in order to be a (good) micro user. Don't give in to this myth: you can do everything you need with the software that comes with your micro or is easily available."

This book is packed with useful ways to use your micro in school. He points out that most college libraries either are computerized now or will be soon. This means students will be able to get most of their library information from their rooms. Micro access of libraries is indoubtedly they way of the future.

Hooking Up To The World

He describes in detail how to hook up micros to the outside world of data banks, libraries and other micros. He even cleared up something that's been bothering me a lot: exactly how to hook up my tiny notebook computer (Texas Instruments CC-40) so I can feed notes made away from home (in a classroom) into my big desktop word processor system, so I can print the information out.

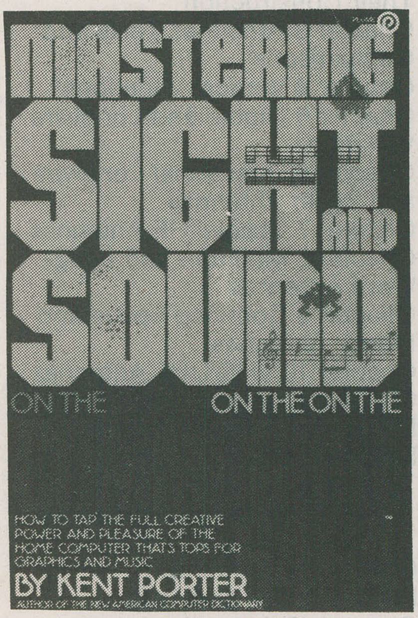
With the exception of the section mentioned in the paragraph above, this excellent book is entirely nontechnical. He describes in adequate detail several notebook (laptop) and *trans*-portable micros good for this work.

This book is a must for anybody in or about to go to college, and as well for high school students who want to maximize their chances of getting ahead faster and further.

Highly recommended

MASTERING SIGHT & SOUND ON THE COMMODORE 64

Kent Porter
261 pages $9.95
Plume/NAL
New York



This latest book by the author of *The New American Computer Dictionary* is a thorough examination of and tutorial for creating graphics and sounds, not only on the Commodore 64 (which is one of the best low-cost computers for these functions) but a good introduction for the serious student to computer graphics and sound in general.

After an introduction to the 64 it discusses computer creation of graphics and sound in BASIC. The fundamentals of graphics, animation, and sound effects are taken up in Chapter 1. All About Bouncing Balls, a 13-step (easy) program to create a bouncing ball on the screen is given, with explanation of how it does that, after the student has typed the program in and observed the ball bouncing aimlessly (at random) about the screen. Screen coordinates (positions) and color are described with learning how to calculate and type in screen positions.

Next, Timing Loops are taken up, then filling shapes to make them solid. Then Adding An Obstacle for the bouncing ball is learned, and then placing obstacles at random, along with simple sound effects. Next we learn graphics to place a horizon, simple house shapes, and adding a fire in a fireplace.

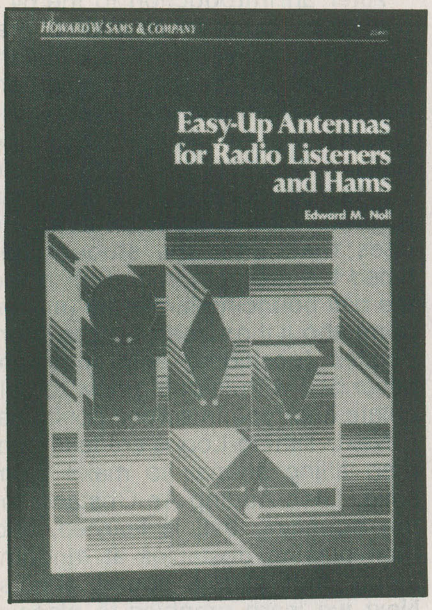
Creation of faces, improving the detail (resolution) and color of characters (animal and people) is taken up, and Movieola, a camera-panning program, (17 lines) with variations is introduced and taught. Simple flying saucers and Sprite (flying objects) are next, along with turning sprites On and Off, expanding sprites, cloning sprites, and positioning them.

Next we learn about creating Starships, changing speeds, firing projectiles, and setting foreground/background priorities. The final chapters get into creation of a sound synthesizer, multisound effects, and at the end, technical Appendixes for learning ASCII, Character Codes, and assembly language, for becoming advanced sight and sound programmers.

Numerous simple programs for learning the basics of sight and sound are presented. All require a Commodore 64, but nothing else beyond a TV set.

An excellent introduction to the way arcade games and adventure programs are created. Tops for the serious beginning programmer, especially if you're into games and graphics.

NEW BOOK REVIEWS



EASY-UP ANTENNAS FOR RADIO LISTENERS AND HAMS
By Edward M. Noll, W3FQJ
220 pages (8½"×11" format); $16.95, Howard W. Sams Co., Indianapolis, IN 46268

"Easy-up Antennas for Radio Listeners and Hams" is a practical antenna book for radio amateurs and prospective radio amateurs as well as for shortwave broadcast, FM broadcast, medium wave broadcast, LW, UTE and scanner radio listeners. All of the basic and some of the more advanced antennas are covered. The antennas are easy to construct, erect and put into operation.

The handbook is in two parts; one for radio listeners and a second for hams. However, the contents of both parts are of value to hams and listeners alike and, the entire book should be read through one time regardless of any special interest.

A special feature of the book is two detailed antenna dimension tables, one at the end of each of the two book sections. Dimensions for all of the basic antenna types are given for the various bands assigned for each radio service. Also several of the columns provide the date needed to fabricate some of the more advanced antennas. Other tables included, provide sets of constants that are useful for making dimension conversions and in calculating antenna length for specific frequencies not given in the dimension tables.

Each antenna presented in the handbook was erected and tested by the author except some of the commercial antennas mentioned in the text. Several of the latter were also purchased and tested. The chapter headings will give you a good perspective of the book content.

Part 1. Radio Receiving Antennas

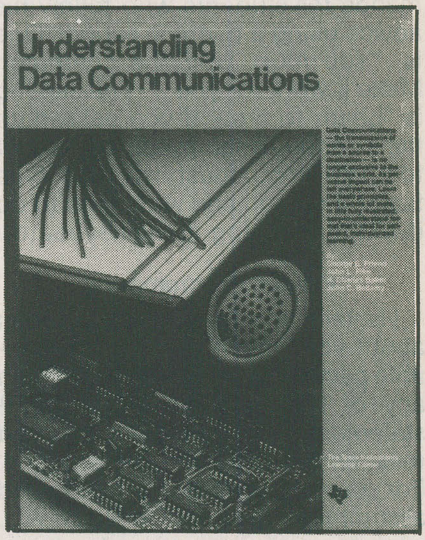
Chapter 1 Radio Services and Book Plan
Chapter 2 Basic Antennas and Their Construction
Chapter 3 Antennas Tests and Comparisons
Chapter 4 Vertical Variations
Chapter 5 Dipole and Longwire Variations
Chapter 6 Directional Longwire and Beam Antennas
Chapter 7 Special HF Antennas
Chapter 8 Medium- and Long-Wave Antennas
Chapter 9 Confined Space and Indoor Antennas
Chapter 10 VHF/UHF Antennas
Chapter 11 International Antenna Dimension Tables for Radio Listeners

Part 2. Ham Radio Antennas

Chapter 12 Antenna Fundamentals and Tests
Chapter 13 Antennas for the New Novice Operator
Chapter 14 Antennas for General- and Advanced-Class Licensees
Chapter 15 Antennas for the New Technician and New VHF/UHF Operators
Chapter 16 International Antenna Dimension Tables for Ham Radio Operators

Appendix Antenna Manufacturers, Sources, and Information

Autographed copies may be purchased from the author ($16.95+$2.00 P&H), P.O.Box #1042 Doylestown, PA 18901



DATA COMMUNICATIONS

The expanded *Understanding Series* by Texas instruments, one of the world's leading high-tech corporations, provides a series of books for the reader interested in today's electronics technology. The latest entry is *Understanding Data Communications* ($19.95—paperback) was prepared by leading authors in the field. Understanding Data Communications shows how digital signals are used to communicate information.

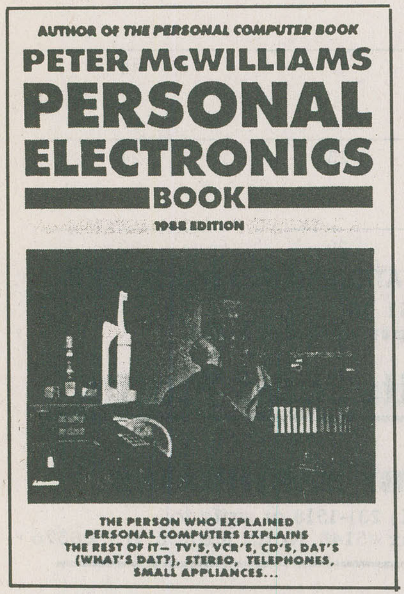
In an easy-to-read style, the book's 272 pages explain in an easy-to-read style the codes used for data communications, the types of messages.

Available in most college bookstores and electronics counters of major bookstores. For more information, write to Texas Instruments Incorporated, P.O. Box225474, M/S 8218, Dallas, TX 75265

THE PERSONAL ELECTRONICS BOOK
by Peter McWilliams (1988 Edition). 216 pages, paper, Prentice-Hall Press. $10.95.

The author of this book first became financially successful by writing about home computers and how to choose one if you knew absolutely nothing about technical matters. He did so writing at the absolute rock-bottom level needed by most consumers, and combining his information with a terrific, and amusing writing style.

This was back in the days when



microcomputers were enjoying their first big sales success in the early Eighties. He followed that sucess with similar books on choosing computers for word processing, and now has written an equally useful and funny guide to choosing personal electronics. This includes just about everything electronic one can use—except small computers—stereo components, car stereo, VCRs, car telephones, 'phone answering machines, and even small kitchen appliances and cameras.

As with his earlier books, McWilliams performs a very valuable service, guiding beginners through the pitfalls (well, most of the pitfalls) of shopping for personal electronics. Because there are so many hundreds of models of each kind of product to choose from he doesn't try to cover all or even most manufacturers. Instead he concentrates on a few makes and models of each kind of device, and his choices are generally quite sound.

He has two introductory chapters which outline in hilarious terms, the "History of Personal Electronics," and "What's All This Fuss About Digital?" These two chapters alone are worth the price of the book. He's included lots of uproarious woodcut illustrations and cartoons. And they alone would make the book a bargain if you were just looking for entertainment.

But the bottom line is, if you're not an expert, this book will pay for itself the first time you spend a hundred or two hundred dollars, following its generally excellent advice. The only thing I don't like about Peter McWilliams is that he wrote these books when I should have.

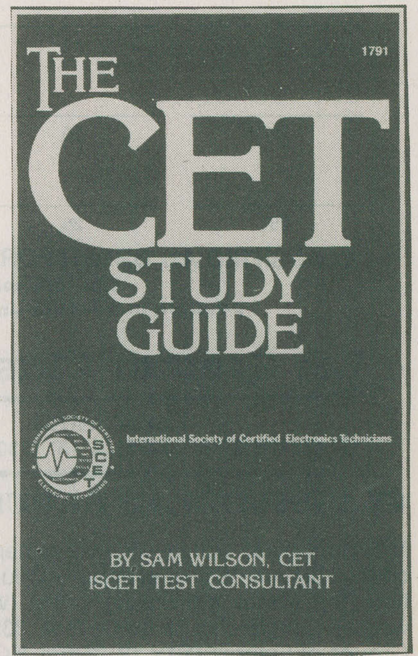
GETTING THE CET TICKET

You're an experienced consumer electronics technician, you want to keep on advancing in your field, and you want to be able to take advantage of the best possible job opportunities. If that description fits you, you should give serious consideration to obtaining your Journeyman Consumer CET Certification! It's the prestigious professional electronic rating granted by ISCET (International Society of Certified Electronics Technicians) that shows you belong in the top echelon of electronics professionals!

Now there's a CET study guide to make preparation for that exam as easy as possible. It's *The CET Study Guide* ($11.95) by Sam Wilson, CET ISCET Test Consultant. This exceptionally complete sourcebook will help you review exactly what you need to know in your consumer electronics specialty exam including theory and practical workbench techniques that deal with TV, radio, VCR, stereo, microcomputer, and other consumer electronics equipment.

There is also a complete 75-question practice exam. The questions are similar to (no—the author does not provide the actual ones used in the exam) you'll find on your CET test. The author has provided answers to all questions, those in the chapter reviews and the practice exam. He's even provided invaluable hints on how you can avoid careless errors when you take actual CET exams.

Sam Wilson is Director of CET



Testing for INCET. His text (paperback, 282 pages) is completely up-to-date and is a practical guide that gives you a comprehensive review of all the topics covered in the exam. Arranged section-by-section, it provides the latest technology on antennas and transmission lines, digital circuits, linear circuits, test equipment and troubleshooting, and much more. Plus, each section includes review questions to help you pinpoint your own strengths and weaknesses. Write to Tab Books Inc., Blue Ridge Summit, PA 17214 to obtain your copy of this title and their latest catalog.

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There will be regular headings and when no heading is requested, our judgement will decide. If you desire a special heading, there will be a $10.00 service charge.

Ads are set in uniform style with the fisrt word in CAPS—Extra CAPS are 40¢ per word.

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We reserve the right to refuse objectionable copy and revise copy to conform to our standards.

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MAIL TO: C&E HOBBY HANDBOOKS—CLASSIFIED.
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Remittance of $ ____________ is Enclosed.

V6

TEST INSTRUMENT ROUND-UP

By Walter Sikonowiz

Things change rapidly in the world of electronics, and nowhere do they change more rapidly than in the field of test instrumentation. If you haven't purchased or seriously examined electronic test gear in, say, the past five years, we guarantee that you are going to feel like Rip van Winkle after reading this article. New instruments, like logic analyzers, have come on the scene; old ones, like the venerable multimeter, have been improved and in almost every case the trend is toward higher performance per unit cost—more bang for the buck, as the engineers say. In this article we are going to survey several of the most important and popular classes of electronic test equipment. We'll take a look at what's available, how much it costs and, in some instances, how to put the equipment to use. Throughout, the emphasis will be on equipment that would be useful to and affordable by the hobbyist and/or experimenter.

Multimeters

The first test instrument that an electronics enthusiast buys is usually a multimeter. Voltage, current, and resistance are the basic quantities measured by a multimeter, though occasionally other functions are included. Multimeters come in four distinct styles. The simplest, and historically the first on the scene, is what's known as a VOM (for volt-ohm-milliameter). Internally, the VOM consists of little more than an analog meter, a handful of resistors, and a switch. Typical DC voltage accuracy is on the order of 2% to 3% of full scale; 1% accuracy is available, but at a higher price. On scales other than DC volts, the error increases by several percent. You can buy a VOM for as little as $10 or as much as $200. The difference in price reflects a difference in accuracy, ruggedness, workmanship, and country of manufacture. Regardless of price, however, all VOMs suffer from a relatively low input impedance that varies from range to range and limits the accuracy with which voltages can be measured.(Remember: accurate voltage measurements cannot be obtained unless the impedance of the meter is much greater than the impedance of the voltage source).

The input-impedance problem was solved, once electron tubes became available, by inserting a high-input-impedance buffer amplifier before the analog meter. The resulting instrument was known as a vacuum-tube voltmeter, or VTVM. The inherent accuracy of the VTVM was about the same as that of the VOM; however, the high input impedance (11 megohms) eliminated many of the errors caused by circuit loading. You might think, as I did, that the

VTVM would be obsolete in this era of solid-state devices. Apparently not, however, because B&K-Precision still offers its Model 177 VTVM. This instrument has an outstanding AC bandwidth of 4 MHz, so maybe that explains its continued existence.

Fig. 1 The Simpson 474 is a 4½-digit handheld digital multimeter with a basic DC voltage accuracy of .03% and a resolution of 10 microvolts or 100 nanoamps on the lowest ranges. (Courtesy of Simpson Electric Co.)

Once the field-effect transistor (FET) was developed, it was only natural that the FET would be pressed into the same service as its predecessor, the vacuum tube. Thus we now have FETVMs with essentially the same characteristics as the older VTVMs. The accuracy of the FET voltmeter is about the same as that of a good VOM (2% to 3% of full scale), but errors that might result from circuit loading are minimized by the 10-megohm input impedance of the FET amplifier. Naturally, an analog multimeter with an FET amplifier costs more than a simple VOM; typical prices range from $100 to $300.

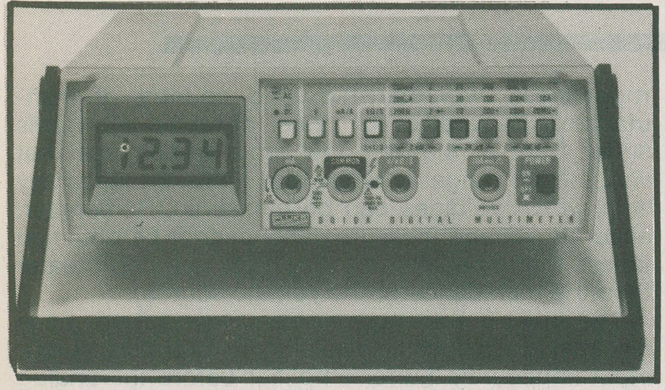

Fig. 2 This bench-style DMM, the Model 8010A from John Fluke, features a basic DC voltage accuracy of .1% and a 3½-digit LCD display capable of resolving 100 microvolts on the lowest range. The unit offers the special capability of true RMS response for AC measurements. (Reproduced with permission from the John Fluke Mfg. Co., Inc.)

The most recent innovation in multimeters has been the replacement of the analog meter with an analog-to-digital converter and a digital display. The digital multimeter (DMM) offers the advantages of high input impedance, superb accuracy, and high resolution at relatively moderate cost, and thus has become tremendously popular. DMMs with 3½, 4½, 5½, and 6½ digits of resolution are currently available. (A half digit can take the value 0 or 1; it is always the leftmost digit in a display.) Higher resolution is generally accompanied by higher accuracy and cost.

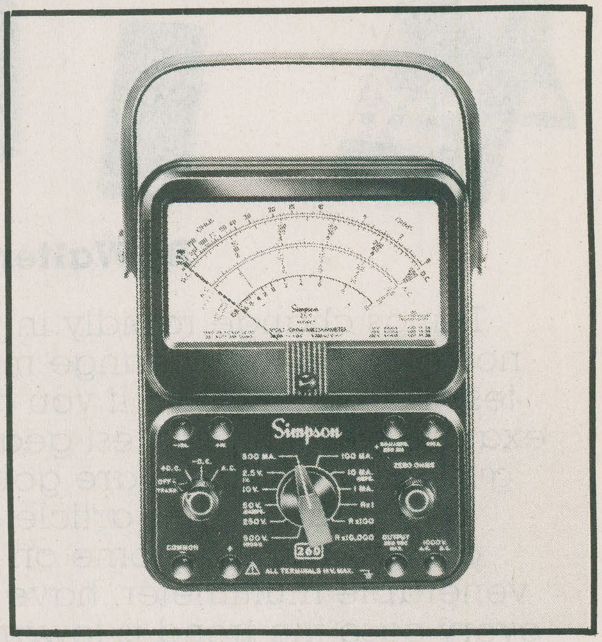

Fig. 3 Simpson's rugged Model 260-7 analog multimeter is accurate to within 2% of full scale on DC, 3% of full scale on AC. Frequency response on the AC ranges extends up to 100 KHz. (Courtesy of Simpson Electric Co.)

For example, making a random search through some catalogs, I found a 3½-digit imported DMM with 0.5% DCV accuracy for $40, a 3½-digit unit with 0.1% DCV accuracy for $120, a 4½-digit model with 0.03% DCV accuracy for $295, and a 5½-digit DMM WITH 0.003% DVC accuracy for $995. With specs and prices like these, you might wonder why the DMM hasn't made all other forms of the multimeter obsolete. One reason is that an analog meter is better at following a changing voltage than a digital meter, since a digital reading is only updated about three times a second. Another reason is that analog meters generate no RF interference, whereas a digital meter will, unless it is very carefully shielded. Finally, some people simply prefer and analog display to a digital one.

So, which multimeter is best for you? If low cost is a top priority, you might choose either a VOM or a low-cost imported DMM. If you prefer an analog meter but need high input impedance, the FETVM is the logical choice. And finally, if high accuracy is a must, then the DMM is your best bet.

Oscilloscopes

The most versatile and valuable test instrument the experimenter can own is the oscilloscope. With the aid of one of these instruments, you can actually see

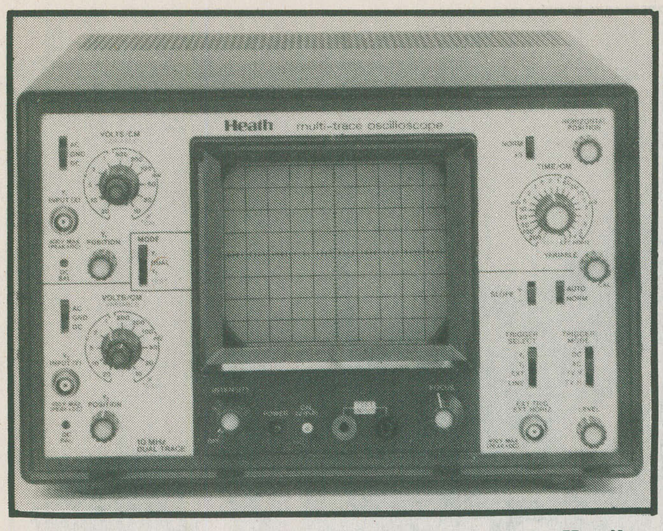

Fig. 4 For those of you who enjoy building kits, Heath offers this IO-4210 dual-trace triggered-sweep oscilloscope with a frequency response of 10 MHz. (Courtesy of the Heath Co.)

what a waveform looks like and, at the same time, measure the waveform's amplitude and period. Scopes are available in a bewildering variety of styles and price ranges. At the very top are the elite lab-grade models. You could pay for one of these with a $10,000 bill and not get back enough change to buy coffee and a doughnut. Since few of us need a scope of that caliber, this discussion will concentrate on instruments costing less than $1,000.

Surveying the current crop of scopes, I soon came to the realization that performance has gone up while prices have come down. Case in point: fourteen years ago I bought a dual-trace 15-MHz oscilloscope from an American manufacturer for $800. Today you can buy a Japanese scope with virtually identical features for half that price. (The difference would be even more spectacular if we took inflation into account.) American scope manufacturers have responded to the competition by cutting their prices as well. For example, the Tektronix 2225 shown in Fig. 5 is a dual-trace 50-MHz scope with the remarkable price of $995.

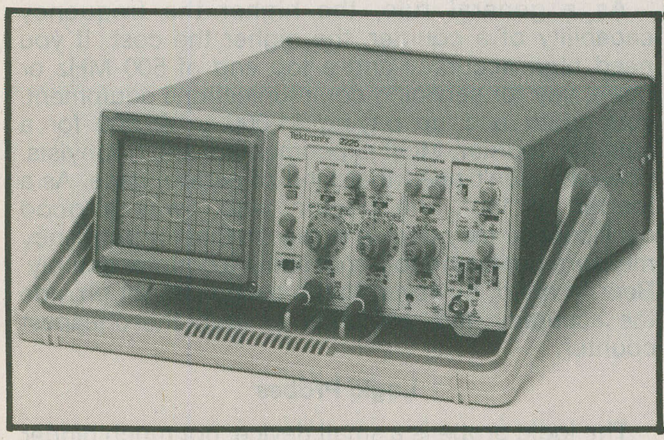

Fig. 5 From Tektronix comes the low-cost Model 2225 portable oscilloscope. This dual-trace unit has a frequency response of 50 MHz and a full complement of triggering options. (Courtesy of Tektronix, Inc.)

Even though prices are down, you should still avoid buying more performance than you can use. In other words, buy a scope whose bandwidth is consistent with your needs. For the beginner, a 10-MHz triggered-sweep oscilloscope with single-or dual-trace capability should be satisfactory, and it probably won't cost more than $300. More experienced users should pick a scope whose bandwidth matches their application, bearing in mind that the bandwidth is the upper frequency limit at which the *sinewave* response of the scope's vertical amplifier begins to roll off (at-20 dB/decade). Thus, a 20-MHz scope will faithfully display a 20-MHz sinewave, but a squarewave of the same frequency will be distorted because the vertical amplifier attenuates vital harmonics. (The harmonic components of a 20-MHz squarewave occur at 60 MHz, 100 MHz, 140 MHz...and upward.) As a general rule, therefore, the bandwidth of your scope should be at least ten times greater than the frequency of the fastest squarewave you plan to observe.

Traditionally, oscilloscopes have used cathode-ray tubes, but recently LCD displays have appeared on several portable scopes. The Leader LCD-100 consists of a 200-kHz scope and a DMM in a book-size package; price is $850. From Tektronix comes the T-201, a 5-MHz scope with built-in DVM and frequency counter; the price of this 10×4×2" package is $1995. Both of these products are digital oscilloscopes, i.e., they convert an analog input to digital form, store it in memory, and display it on the LCD. Field-service engineers and technicians are the people most likely to benefit from an LCD scope.

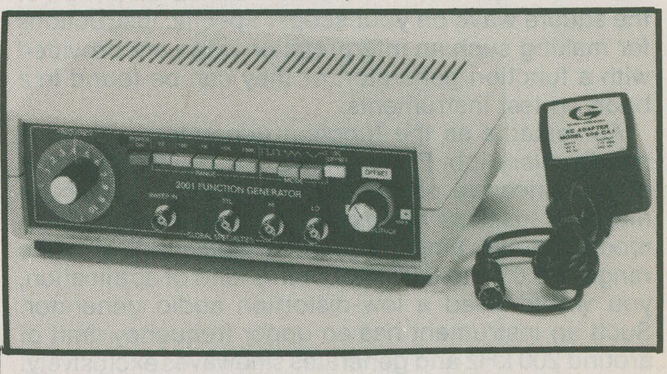

Fig. 6 The Model 2001 sweepable function generator from Global Specialties generates sine, square, and triangular waveforms in five frequency ranges. Maximum output frequency is 100 KHz. (Courtesy of Global Specialties, an Interplex Electronics company)

Signal Generators

A signal generator provides the experimenter with a handy source of AC waveforms whose characteristics—such as frequency, amplitude, and shape—can be adjusted to suit the application. Typically, a signal generator supplies the waveforms that are needed during the design, testing, or repair of electronic equipment. Perhaps the most popular form of signal generator among experimenters and hobbyists is the function generator. This versatile piece of equipment generates three different waveshapes: sine, square, and triangle. The square

and triangle waveforms are usually generated simultaneously by an integrator/Schmitt trigger type of oscillator. The sine is then derived from the triangle by means of a resistor-and-diode network that rounds off the sharp corners of the triangle wave, thus producing a reasonable approximation of a sine with 1% to 2% distortion. The frequency range of the function generator normally extends from well below 1 HZ to a couple of MHz or so. In a properly designed unit, the output amplitude is independent of the operating frequency. Most function generators fall into the $100-$300 price range, though some high-quality units cost considerably more.

The three waveforms provided by a function generator can be put to a variety of uses. For example, the sinewave can be used to test the frequency response of an audio amplifier. Simply feed a low-level sinewave into your amplifier's AUX or TUNER input and observe the amplifier's output on a scope. Take note of the output amplitude at 1 kHz, and then increase the frequency until the indication on the scope drops to the 70% of its value at 1 kHz. The frequency where this occurs is your amp's upper -3 dB frequency limit.

Square waves can be used to provide the clock signals needed by digital circuitry. Furthermore, because square waves have a rich harmonic content, they can also be used for quick evaluation of an amplifier's frequency response. If you feed a square wave of the proper frequency to an amplifier's input and observe the output of the amplifier on a scope, any deficiency in the amplifier's frequency or transient response will manifest itself as distortion of the square wave on your scope. Specific instructions for making such an interpretation often are provided with a function generator, or they can be found in a book on test instruments.

As versatile as the function generator is, it won't handle every job. For example, the 1%-2% distortion of the sinewave produced by a function generator makes it useless for assessing the distortion of a modern audio amplifier, which typically lies in the range of 0.01% to 0.001%. For this kind of application, you would need a low-distortion audio generator. Such an instrument has an upper frequency limit of around 200 kHz and generates sinewaves exclusively.

Another handicap of the function generator is its inability to generate signals in the radio-frequency range. Thus, for work involving radio transmitters and receivers, you need an RF signal generator capable of supplying low-distortion sinewaves in the range from 100 kHz to perhaps 100 MHz.

Finally, you may find in digital applications that the function generator fails to provide the kind of timing signals needed. In that case, what the job probably demands is a pulse generator, a device that allows precise, independent control of both the repetition rate and the width of the pulses it generates.

Despite the shortcomings outlined above, the function generator really is the best choice as the first—and perhaps only—signal generator purchased by most experimenters. An audio generator, or a pulse generator, or an RF generator can always be purchased later if the need arises.

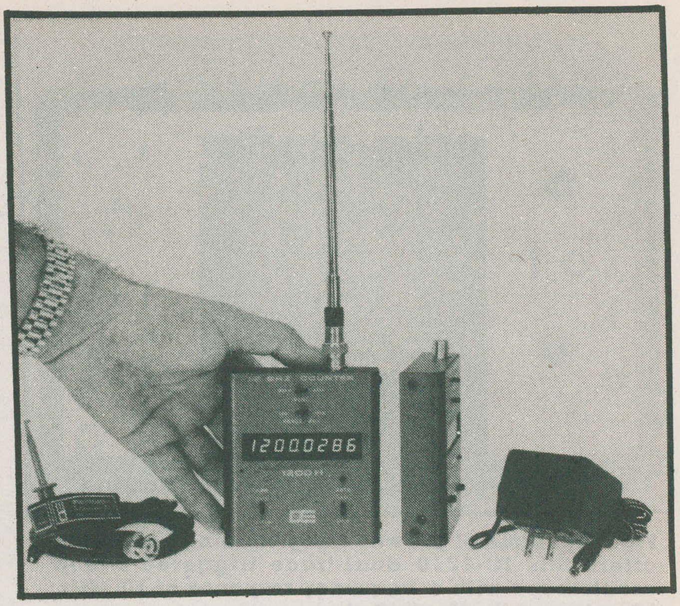

Fig. 7 Suitable for use in the field or on the test bench, the Model 1200H handheld frequency counter from Optoelectronics has an 8-digit LED display and a maximum operating frequency of 1.2 gigahertz. Unit is available in kit form or fully assembled. (Courtesy of Optoelectronics, Inc.)

Frequency Counters

Before the advent of the digital frequency counter, frequency was measured with an oscilloscope or an analog frequency meter. Both methods provided an accuracy no better than about 3%. Today, even an inexpensive digital frequency counter can have a timebase accuracy of 0.001%, while the more advanced units boast accuracies of 0.0001% or better. What's interesting is that such accuracy is available at a relatively low price. A bare-bones 50-MHz counter with an 8-digit display can be had for less than $100, while a more advanced unit, sporting such features as a temperature-compensated crystal timebase and the ability to measure period and to totalize counts, won't cost much more than $400. The reason for the low cost is that most of the counting functions are built into one or two inexpensive LSI chips.

As a general rule, the higher the frequency capability of a counter, the higher the cost. If you need high accuracy and a top end of 500 MHz or more, say for servicing communications equipment, you could end up paying $1,000 to $5,000 for a suitable counter. Most experimenters and hobbyists, however, don't need that kind of performance. As a matter of fact, the person who owns a good oscilloscope may decide to rely on that for frequency measurements and to forget about a counter entirely. Bear in mind, however, that a scope cannot provide the accuracy and resolution of even the cheapest counter.

Logic Probes

The logic probe is a small device, not much bigger than a pen, that is used to check the state of digital logic. When you touch the logic probe's tip to an IC pin, the probe indicates, by means of a couple of LEDs, whether the node under examination is high,

low, or alternating between these two states. If the probe is designed to be used with different logic families, like CMOS and TTL, its switching threshold will be adjustable. The better probes have a pulse-catching feature that registers the presence of brief transient pulses that would ordinarily be missed by the user. Probes cost from $20 to $50 and are quite useful when troubleshooting a circuit. However, you need more than a simple logic probe to analyze the behavior of a complicated digital circuit.

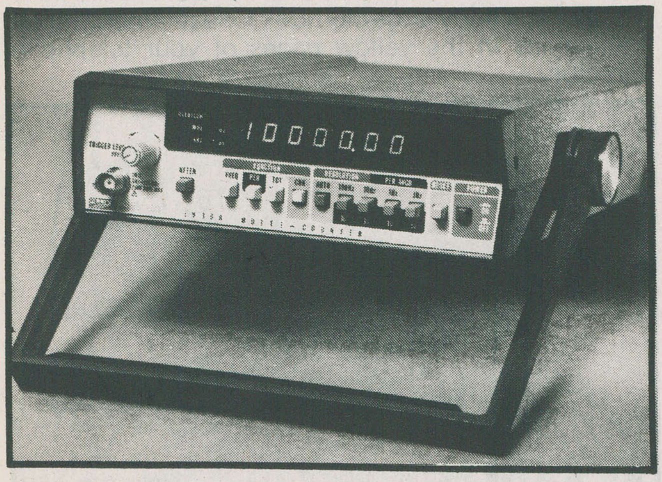

Fig. 8 The Fluke 1910A multi-function counter with 7-digit LED display measures frequency in the range from 5 Hz to 125 MHz. In addition, the unit will compute the period of a waveform or keep a running count of the number of pulses received. (Reproduced with permission from the John Fluke Mfg. Co., Inc.)

Logic Analyzers

The design, testing or repair of complex digital systems, especially those that are microprocessor-based, requires the use of a logic analyzer. This is a device reminiscent of a multi-channel oscilliscope, but with special features added for digital analysis. When logic analyzers first appeared in the 1970's, two types of instrument were available: the logic-state analyzer, and the timing analyzer. Today, logic-analyzer manufacturers are more apt to offer both state and timing analysis in the same package, but single-function instruments are still around.

All logic analyzers are multichannel recorders of digital information; the number of channels varies from 16 to 64. When the analyzer is triggered, it captures binary information, stores it in memory, and then displays it in a variety of useful formats on a CRT screen. The distinguishing characteristic of the logic-state analyzer is that it grabs information whenever the system under test is clocked. If we attach a logic-state analyzer to the address and data lines of a microprocessor, we will see the states through which the microprocessor is cycling as it executes its program. A raw data display might look something like this:

1000	**0100**
0110	**0011**
1110	**0010**
0010	**1011**

To make that information easier for a human to comprehend, advanced logic analyzers will convert the address-line data to hexadecimal and the data-line information to assembly language or hex, as appropriate. The resulting display might appear, in part, like the following:

ADDRESS	OP CODE/DATA
5A01	LDA
5A02	12
5A03	22
1222	76
5A04	MOV

This is similar to a standard assembly-language program listing, with some extra information thrown in. It would be readily intelligible to anyone familiar with the assembly language of the microprocessor under test. The user would be able to trace the step-by-step execution of the program and see what, if anything, was going wrong.

A timing analyzer differs from a state analyzer in that it samples data at a rate *faster* than the clock rate of the system under test. This information is stored in memory and then displayed as in Fig. 10, where we see the voltage-vs-time relationships for four signal lines. With this sort of display, we can tell whether signal transitions are occurring at the proper time relative to other signals in the system. The timing-analyzer display will also show glitches, those unpredictable and undesirable transient pulses that can disrupt the operation of a logic system. If timing relationships are incorrect or glitches appear, a system's hardware must be redesigned.

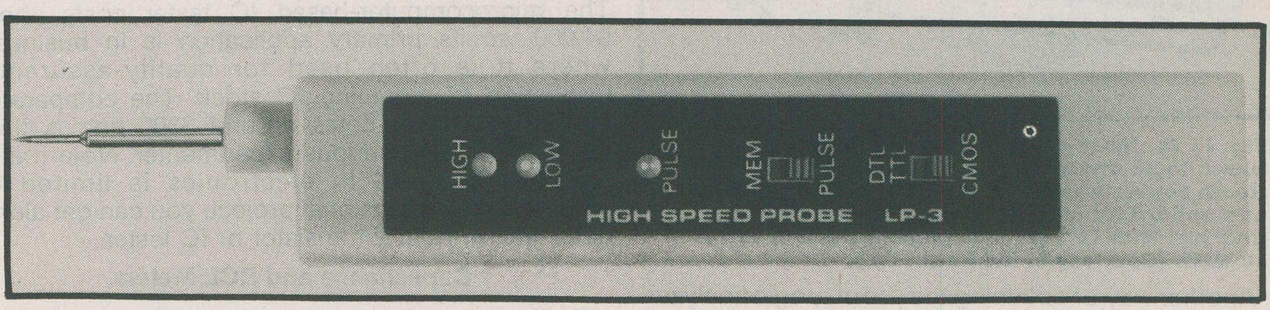

Fig. 9 This LP-3 logic probe from Global Specialties works with CMOS or TTL logic at frequencies up to 50 MHz. A pulse-memory feature allows pulses as brief as 10 nanoseconds to be captured and observed. (Courtesy of Global Specialties, an Interplex Electronics company)

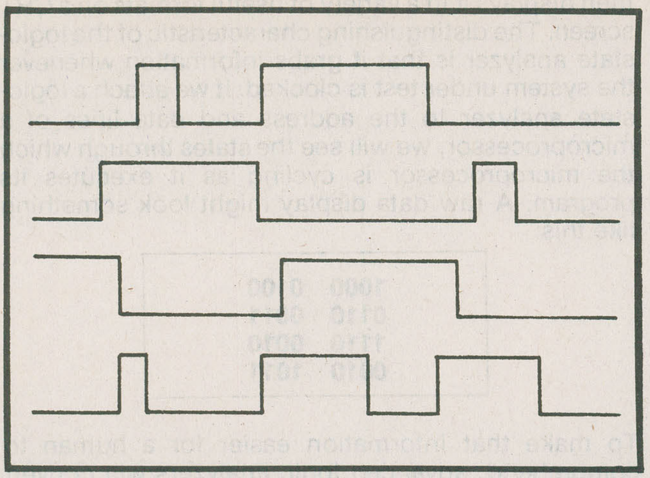

Fig. 10 Typical timing analyzer display. Vertical scale represents voltage, horizontal scale time. Activity on four separate data lines is compared in this display.

Now that the usefulness of a logic analyzer has been established, you're probably wondering what one of these things costs. Well, hold onto your hat: prices range between 3,000 and 20,000 dollars. That's a bit expensive for most experimenters. However, if you already own a personal computer and are willing to forgo some frills, it is possible to acquire the capabilities of a logic analyzer at a more reasonable price. You do this by buying a logic-analyzer adapter like the Heath IC-1001 shown in Fig. 11, which sells for $269. Used in conjunction with an IBM PC-compatible personal computer or a standard terminal, the IC-1001 is claimed to provide most of the capabilities of a full-fledged logic analyzer. (Note: Other companies make similar adapters. I choose the Heath unit for illustration because it was by far the least expensive unit I encountered, and because it appears to work with any personal computer equipped with a serial port and communication software.)

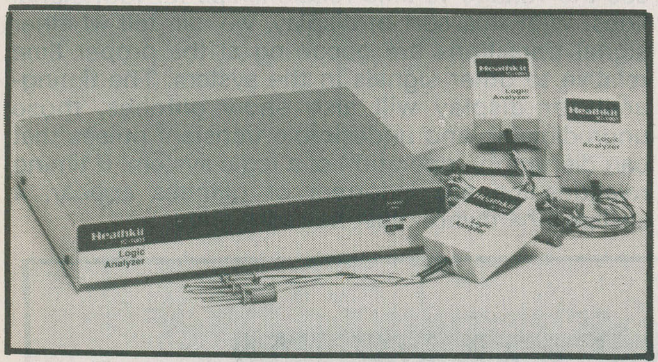

Fig. 11 For those of you unable to afford a full-blown logic analyzer, this Model IC-1001 kit from Heath converts your IBM PC-compatible computer or standard terminal into a logic state/timing analyzer with 16 inputs. Maximum clock speed is 10 MHz. (Courtesy of the Heath Co.)

Another way of obtaining the use of a logic analyzer at reasonable cost is to lease it. This is the option most often used by business in need of a prohibitively expensive or seldom used piece of equipment. Of course, logic analyzers are not the only things you might want to rent. Expensive oscilloscopes, signal generators, and all manner of other test instruments can be leased. The cost per month is from 5% to 10% of the manufacturer's list price, usually with a minimum rental period of one month. So, a $5,000 logic analyzer might cost $500 a month to rent. Obviously, leasing makes sense only if you stand to make a profit from the use of the instrument; it's not for weekend tinkerers. You'll find a listing of some of the major rental companies at the end of this article. If you live in a fairly large city, look for equipment-rental companies in the yellow pages of your telephone directory.

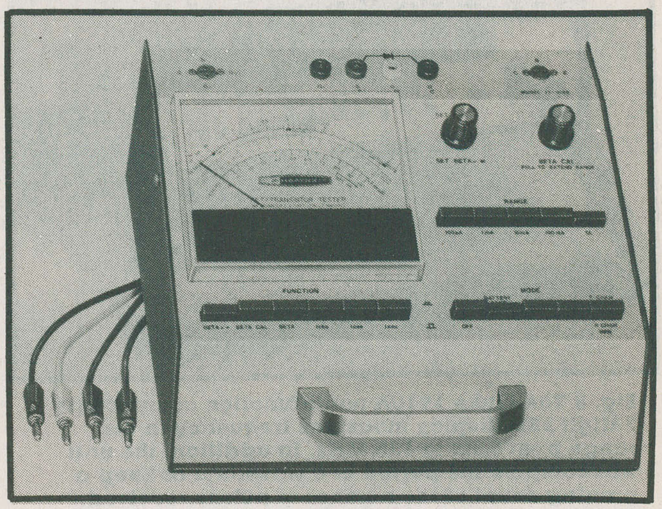

Fig. 12 Transistors, diodes, FETs and a variety of other solid-state components can be tested with the aid of this Heath IT-3120 semiconductor checker. (Courtesy of the Heath Co.)

Semiconductor Testers

For someone who does maintenance and repair work on electronic equipment, a semiconductor tester is a necessity. The unit illustrated in Fig. 12 is capable of checking discrete components like transistors, FETs, diodes, and so forth. You'll also find integrated-circuit testers on the market. The simplest form of IC tester is known as a comparator; it evaluates an IC by comparing its performance with a reference IC that is known to be good. The other form of IC tester is microcomputer-based, and can hold in its memory the complete electrical specifications for literally thousands of ICs, including, for example, all the members of the TTL and CMOS logic families. The microcomputer-based IC tester costs about $4,000, so its primary application is in business, where it is often used for quality-assurance inspection of incoming IC stock. The comparator type of IC tester costs around $300 and is thus affordable by the serious experimenter. Note that if your involvement in electronics is limited to assembling an occasional project, you can get along quite well without a transistor or IC tester.

Capacitance and RCL Meters

Capacitance and inductance have traditionally been measured on a reactance bridge. Such bridges are still used today, but digital capacitance meters, like the one in Fig. 13, and digital RCL meters are

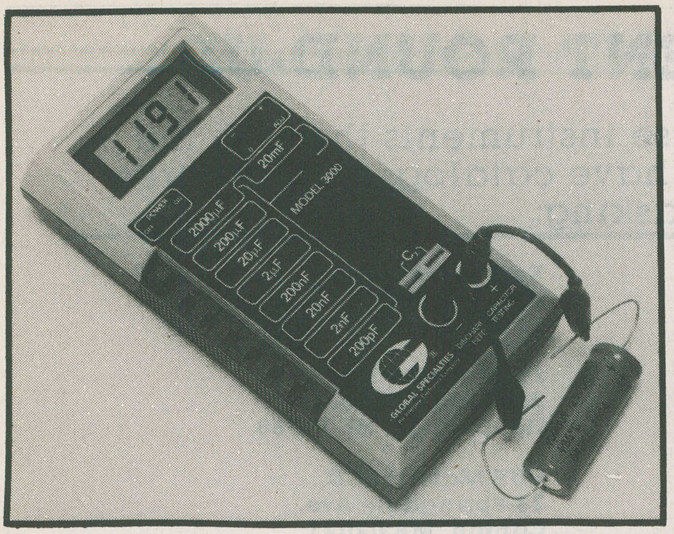

Fig 13. The Model 3000 digital capacitance meter from Global Specialties has a 3½-digit LCD display and nine measurement ranges: 200 pf to 20,000 mf full scale. Basic accuracy is .5% on the six lower ranges, and 1% to 2% on the upper ranges. (Courtesy of Global Specialties, an Interplex Electronic company)

gradually taking over. The reason for this is that the digital instruments are quicker to use; also, the digital display is bright and unambigious. Digital capacitance meters and RCL meters are available for $100 to $200 and are a worthwhile acquisition for someone who already owns the basic instruments like a scope and multimeter.

Power Supplies

Every experimenter should own an adjustable, regulated DC power supply. You can either build your own—it's fairly easy—or buy one of the reasonably priced commercial units. A basic power supply should have a metered output and be capable of providing 0-20 VDC at one amp or more. Even better is the popular triple-output power supply, an example of which appears in Fig. 14. Such a unit will feature a+5-volt output for TTL, and two independent 0-20 volt outputs that can be used, for example, to supply the positive and negative voltages required by op amps. The more expensive power supplies offer features like current-limiting and voltage-tracking, but these are frills the average user will hardly ever need. Concentrate instead on current capability and buy the heftiest supply you can afford, because the really interesting projects have a habit of gobbling up more current than you ever thought you'd need. Half an amp is the minimum capability; one to three amps is better.

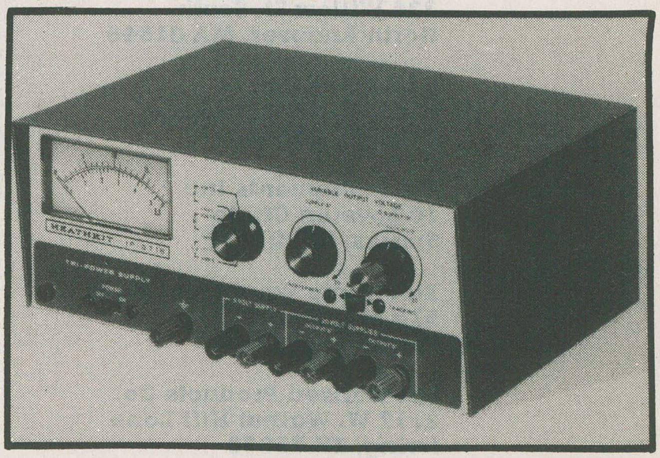

Fig. 14 The Heath IP-2718 DC power supply has one fixed output that provides +5 volts at 1.5 amps and a pair of independently adjustable outputs that supply 0-20 volts at half an amp. (Courtesy of the Heath Co.)

Conclusion

If some of the instruments featured here have whetted your interest, you can write directly to the manufacturers for more data. (See the list of addresses elsewhere in this article.) Most test-instrument manufacturers will also furnish you with a full-line catalog free of charge. Included with manufacturers in the address list are a number of dealers who sell test instruments. All of these dealers have catalogs that are free for the asking. Finally, if you would like to lease a test instrument, you can request further information and a price list from one of the leasing companies on the list. ■

For further information about specific test instruments mentioned in the text, write directly to the manufacturers listed below:

B&K Precision/Dynascan
6460 W. Cortland St.
Chicago, IL 60635

John Fluke Mfg. Co.
P.O. Box C9090
Everett, WA 98206

Heath Company
P.O. Box 1288
Benton Harbor, MI 49022

Hitachi Denshi America Ltd.
175 Crossways Park West
Woodbury, NY 11797

We gratefully acknowledge the following companies for their photographic contributions to our cover and/or the "Test Instrument Round-up" feature in this issue:

OK INDUSTRIES, INC.
HEATH COMPANY
JOHN FLUKE MFG. CO.
INTERPLEX ELECTRONICS
SIMPSON ELECTRIC CO.
OPTOELECTRONICS, INC.

Interplex Electronics Inc.
70 Fulton Terrace
New Haven, CT 06509-1942

Optoelectronics, Inc.
5821 N.E. 14th Ave.
Ft. Lauderdale, FL 33334

Simpson Electric Co.
853 Dundee Ave.
Elgin, IL 60120

Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077

TEST INSTRUMENT ROUND-UP

If you would like to purchase instruments through the mail, the following retailers have catalogs that are free for the asking:

Contact East
335 Willow St. South
North Andover, MA 01845

C&S Sales Inc.
8744 W. North Terrace
Niles, IL 60648

EIL Instruments Inc.
10 Loveton Circle
Sparks, MD 21152

Electronic Equipment Bank
516 Mill St. N.E.
Vienna, VA 22180

Specialized Products Co.
2117 W. Walnut Hill Lane
Irving, TX 75038

Time Motion Tools
410 South Douglas St.
El Segundo, CA 90245

Emco Electronics
P.O. Box 327
Plainview, NY 11803

Fordham Radio
260 Motor Parkway
Hauppauge, NY 11788

HUB Material CO.
33 Springdale Ave.
Canton, MA 02021

Jensen Tools Inc.
7815 S. 46th St.
Phoenix, AZ 85044

Transcat Instruments
P.O. Box D-1
Rochester, NY 14606

Tucker Electronics Co.
1717 Reserve St.
Garland, TX 75042

Finally, for those of you interested in renting instruments that might be too expensive to purchase, the following companies should be consulted:

Advanced Test Equipment Rentals
2633 Ariane Drive
San Diego, CA 92117

Electro Rent Corp.
4209 Vanowen Pl.
Burbank, CA 91505

Leasametric Instrument Rental Div.
1164 Triton Drive
Foster City, CA 94404

U.S. Instrument Rentals Inc.
2988 Campus Drive
San Mateo, CA 94403

Genstar Rental Electronics Inc.
6307 DeSoto Ave., Suite J
Woodland Hills, CA 91367

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CIRCUIT FRAGMENTS

One of the best ways to begin your mastery of electronic circuitry construction is to work with discrete components before diving headlong into integrated circuit construction. After all, integrated circuits are nothing more than these individual components and circuits in a more compact package. The only problem is that they don't come in see-through packages to help you identify the individual working areas.

We don't feel that it's of much value to simply "plug in" black boxes without the understanding of what actually goes on inside them. If you can learn what the circuitry of an integrated circuit is suppossed to do, then it frees you to come up with your own innovations, and to accurately troubleshoot your creations when you run into the inevitable bugs or "glitches."

This brings up another point. While some ICs are relatively sensitive to miswiring and are easily destroyed, these discrete components, as a rule, are not. It's a lot better to make your mistakes here than on an integrated circuit project, where ruining an IC due to a reversed diode polarity might set you back two or three dollars. So have fun, but learn!

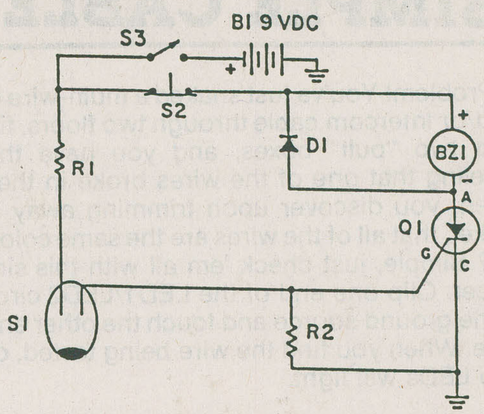
EQUIPMENT THEFT ALARM

As an electronics hobbyist, you very likely own one or more pieces of expensive equipment, and these can be very tempting targets for thieves or vandals. To protect your investment, why not install the simple alarm pictured here in some of your more valuable possessions? Things like Amateur or CB transceivers, computers, oscilloscopes and stereo equipment are ali excellent candidates.

In the schematic, mercury switch S1 is normally open. However, should the equipment in which the alarm has been installed be picked up and tilted, S1 closes and thereby supplies gate current to the SCR. Q1 then latches in a conducting state, causing current to flow through buzzer BZ1. The buzzer will sound until pushbutton S2 is pushed to reset the circuit. For best results, use an electromechanical, rather than piezoelectronic buzzer, since it will emit more noise.

PARTS LIST FOR EQUIPMENT THEFT ALARM

B1—6,9, or 12-volt battery
BZ1—6,9, or 12-volt buzzer
D1—1N4002 diode
Q1—2N5060 SCR
R1, R2—4,700-ohm, ½-watt resistor
S1—normally open SPST mercury switch
S2—normally closed pushbutton switch
S3—SPST toggle swtich

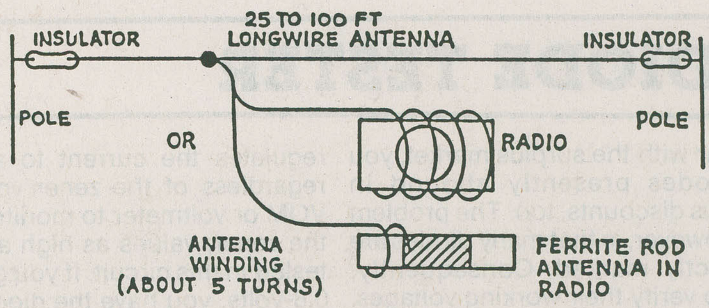


PASSIVE AM BOOSTER

Your transistor radio antenna system is designed to pull in local broadcast-band stations that are either local or very high power—you need a signal with oomph! Now you can make that "one lunger" more sensitive and try some DX with the Passive BC Booster. Also, for those people who work in or live in buildings that effectively kill BC signals, this Passive BC Booster can bring life to that transistor radio that could only detect the noise from fluorescent lamps.

All you have to do is simply bring in the end of an outdoor "longwire" antenna and wrap the end around the radio about 5 times.

Even better reception is possible if you open the radio and wrap about 5 turns around the rod antenna immediately adjacent to the antenna coil mounted on the rod. Make certain the ends of the outdoor antenna are insulated with glass or ceramic insulators. In fact, often an insulated wire about 10-to 20-feet long that is left dangling out a high-story window is all that is needed for an antenna.

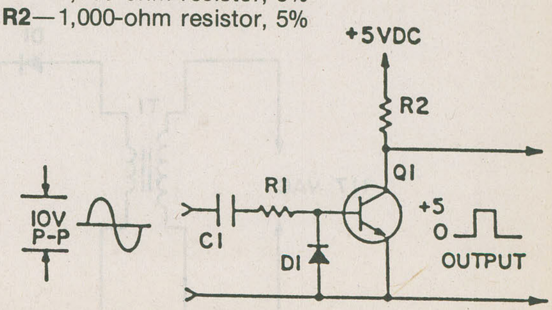


SQUARE WAVE CONVERTER

Got a yen to go digital but few bucks to spend? Well, if you happen to have an old audio signal generator at hand, you can convert its sinewave output to a squarewave and save yourself the expense of a squarewave generator. The converter consists of an ordinary saturating transistor switch which, when driven by a large amplitude (about 10-VDC peak-to-peak or greater) sinewave, yields squarewaves with reasonably fast rise and fall times. Be certain to use as large an input amplitude as possible. Certain edge-triggered ICs, TTL flip-flops in particular, may fail to clock on a waveform whose rise and fall times are too long; however, the majority of ICs will clock readily when driven by this converter.

PARTS LIST FOR SQUARE WAVE CONVERTER

C1—1.0-uF, 25 VDC non-polarized mylar capacitor
Q1—2N3904 NPN transistor
R1—4,700-ohm resistor, 5%
R2—1,000-ohm resistor, 5%



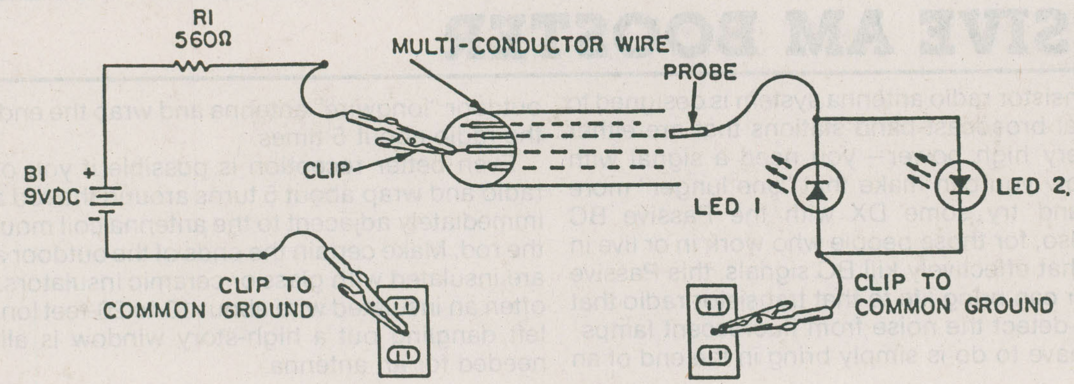
SIMPLE CABLE TRACER

Problem! You've just snaked a multi-wire computer and/or intercom cable through two floors, five bends, and two "pull" boxes, and you have the creepy feeling that one of the wires broke in the process. Then, you discover upon trimming away the outer jacket, that all of the wires are the same color. What to do? Simple, just check 'em all with this simple wire tracer. Clip one end of the LED1/LED2 circuit to the same ground source and touch the other end to each wire. When you find the wire being tested, one of the two LEDs will light.

It doesn't matter which LED lights. We use two only to prevent confusion in the event a polarity gets reversed. This way, one LED is certain to light. The LEDs can be any "general purpose" type available. Battery B1 is a 9-volt transistor radio-type.

PARTS LIST FOR CABLE TRACER

B1—9 volt transistor radio battery
LED1, LED2—general purpose LED, 0.02 mA
R1—560-ohm, ¼-watt resistor
Misc.—3 alligator clips, 1 test probe



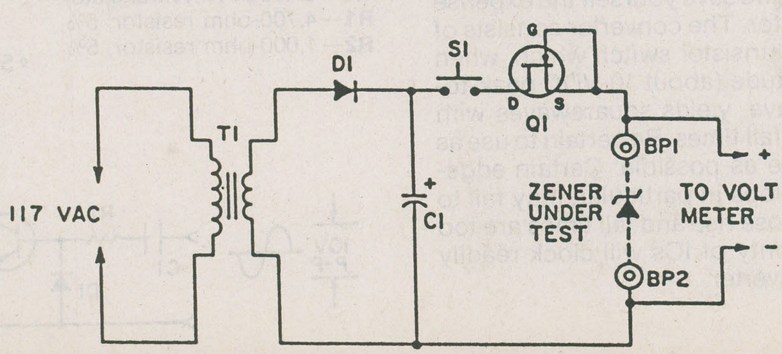
ZENER DIODE TESTER

If you're at all familiar with the surplus market, you know that zener diodes presently abound in surplus—at tremendous discounts, too. The problem with buying surplus, however, is that many diodes are unmarked or incorrectly marked. Consequently, these must be tested to verify their working voltages. Another problem crops up when you buy so-called "grab bags" of components. The zeners you find may be legibly marked, but unless you happen to have a data sheet for those particular diodes, they will require testing to identify the zener voltages. You can do your testing quickly and easily with the circuit presented here.

T1, D1 and C1 comprise a simple half-wave rectifier system. Pressing S1 sends a DC current through current limiter Q1 and the diode under test. Q1 regulates the current to a value of about 10 mA regardless of the zener voltage. You can use your VOM or voltmeter to monitor the voltage drop across the zener; values as high as 25-volts can be reliably tested in this circuit. If you get a very low reading, say 0.8-volts, you have the diode in reverse. Interchange the zener's connections.

PARTS LIST FOR ZENER DIODE TESTER

BP1, BP2—binding posts
C1—500-uF, 50-VDC capacitor
D1—1N4002 diode
Q1—2N5363 n-channel JFET
S1—normally open SPST switch
T1—120-VAC to 24-VAC @ 300 mA power transformer



AM RADIO RF BOOSTER

You can greatly increase the pickup distance of your transistor radio (or even an AM table radio) by adding an RF (radio frequency) stage and then coupling that boosted signal to the receiver's built-in antenna loopstick (ferrite rod). This is a low-cost project that can pack a lot of extra sensitivity into an ordinary radio and it'll let you do broadcast-band DX'ing with that little radio you thought was just for listening to local stations.

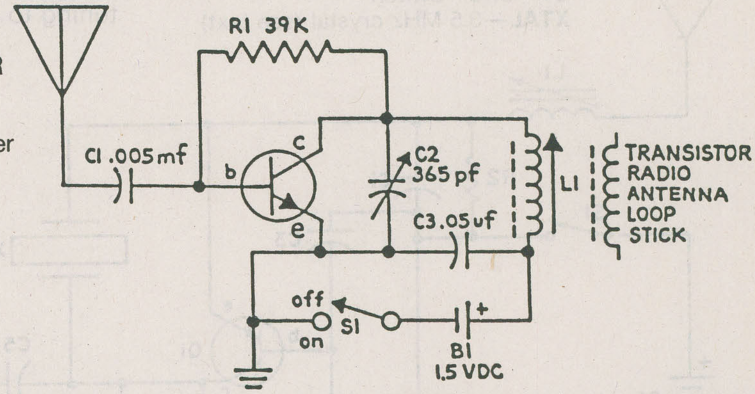
Assemble the circuit in a small plastic cabinet with coil L cemented to the side or back of the cabinet. You can use almost any epoxy, adhesive, or cement.

Connect at least 15 feet (up to 80 feet is even better) of antenna wire (even covered telephone wire or flat TV wire will do temporarily) to input capacitor C1. Position the booster case flat against your radio with L1 as close to the set's loopstick antenna which is built into the radio. Now tune capacitor C2 to the frequency of the station you want to pick up.

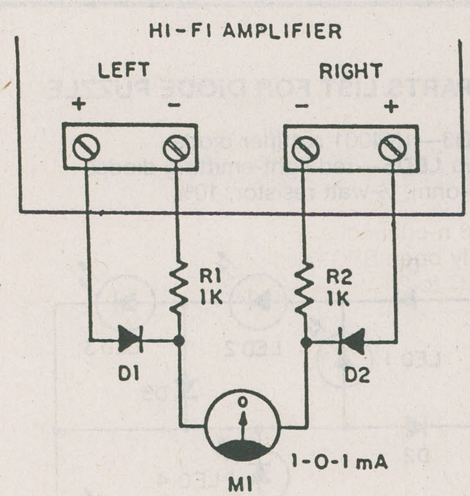
Then turn on the radio and listen to the signals booming in. Remember that the radio set's AVC action will cut down normally-loud local signals.

PARTS LIST FOR AM BOOSTER

B1—1.5-volt penlight AA battery
C1—0.005-uF disc capacitor, 25 VDC or better
C2—365-pF miniature tuning capacitor
C3—0.05-uF capacitor, 25 VDC or better
L1—Loopstick for C1
Q1—2N1304 NPN transistor
R1—39,000-ohm, ½-watt resistor
S1—Spst switch (on-off)



STEREO BALANCE METER



The only way to be certain your sound system is in perfect electrical balance is to use a power amplifier stereo balance meter to substitute for guesswork.

Meter M1 can be a zero-center DC milliammeter rated 1-0-1 mA or less. Alternatively, you could use a standard meter but the pointer might be driven off-scale to the left while making adjustments, though the meter won't be damaged—it will just be an inconvenience.

Play any disc or tape and then set the amplifier to *mono*. Adjust the left and right channel balance until meter M1 indicates zero; meaning the left and right output level are identical—that's balance.

PARTS LIST FOR STEREO BALANCE METER

D1, D2—Silicon rectifiers rated 100 PIV at any low current
M1—Zero-center DC mA meter (see text)
R1, R2—1000-ohm resistors, 5% or 1%

ADD LONG WAVE TO SHORT WAVE SET

PARTS LIST FOR SHORT WAVE SET

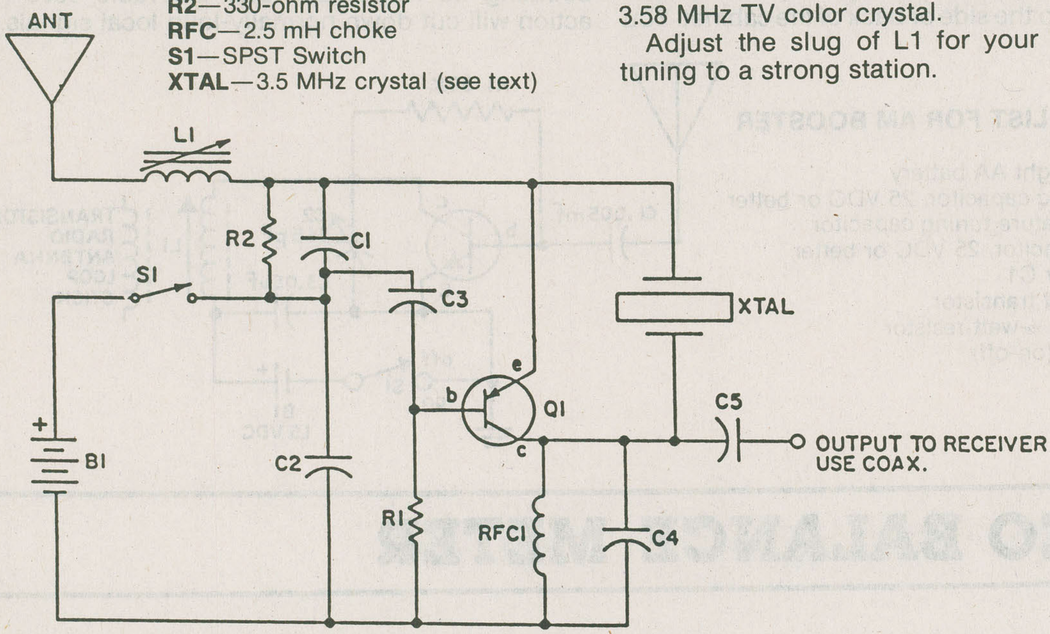
B1—9VDC battery
C1, C4—470-pf capacitor
C2—.1-uF capacitor
C3—.001-uF capacitor
C5—50-pf capacitor
L1—Loopstick coil
Q1—PNP transistor, 2N3906 or equiv.
R1—470,000-ohm resistor
R2—330-ohm resistor
RFC—2.5 mH choke
S1—SPST Switch
XTAL—3.5 MHz crystal (see text)

Ever listen in on the long waves, from 25-500 kHz? It's easy with this simple converter. It'll put those long waves between 3.5 and 4.0 MHz on your SWL receiver.

Q1 acts as a 3.5 MHz crystal oscillator, mixing the crystal frequency with the long wave input from the antenna and forwarding the mix to your receiver.

L1 is a standard broadcast loop stick antenna coil. The crystal is available from many companies by mail order, or at a ham radio store. You could also use a 3.58 MHz TV color crystal.

Adjust the slug of L1 for your best signal after tuning to a strong station.

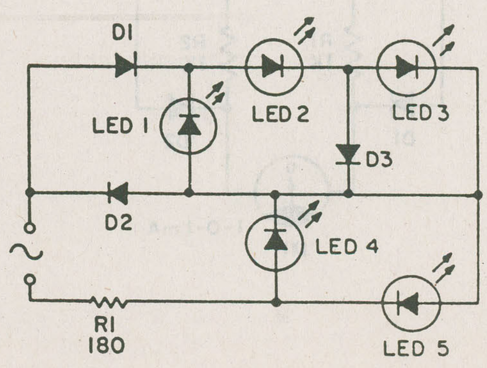


DIODE PUZZLE

This innocuous-looking little circuit will provide a good indication of how well you really understand the rectifier diode and the light-emitting diode. Your task is to determine which of the five LEDs will light up when 6.3 volts AC is applied to the circuit. We won't give you the answer; to find that out, just breadboard the circuit. However, we will supply you with a couple of hints. First, the forward voltage drop of a rectifier diode is approximately .8 volt, while that of an LED is about 2 volts. Naturally, rectifiers conduct in one direction only. LEDs will light up only when their anodes (arrows) are 2 volts more positive than their cathodes (bars). Finally, you can expect to find 3 LEDs lit and 2 LEDs dark. Pencils sharpened? OK, begin.

PARTS LIST FOR DIODE PUZZLE

D1, D2, D3—1N4001 rectifier diode
LED1 thru LED5—red light-emitting diodes
R1—180-ohm, ½-watt resistor, 10%



FREQUENCY DIVIDER

Mention the topic of frequency division, and immediately most of us start thinking in terms of TTL, CMOS or some similar family of digital integrated circuits. In fact, surprising though it may seem, frequency division can be readily accomplished without ICs using common discrete semiconductors-in this case, a unijunction transistor.

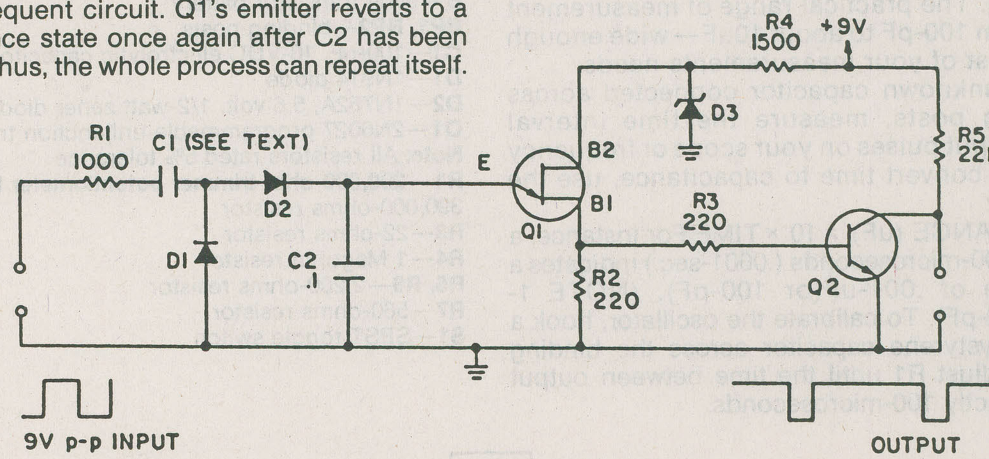
Capacitors C1 and C2 together with diodes D1 and D2 constitute a simple *charge pump,* which feeds the emitter of UJT Q1. Normally, C1 is chosen to be smaller than C2, and in this circuit values of C1 between .02 and .1 mf should be satisfactory. With each positive-going transition of the digital input signal, C1 transfers a small amount of charge to C2, which acts as a reservoir. This accumulated electronic charge is prevented from leaking away by D2. As successive input pulses transfer more and more charge to C2, the voltage across C2 naturally rises.

Eventually, the voltage on C2 will become high enough to cause Q1's emitter to break down and discharge C2 through R2. When this happens, Q2 amplifies and inverts the voltage pulse appearing across R2. This amplified pulse may then be used to clock a subsequent circuit. Q1's emitter reverts to a high-impedance state once again after C2 has been discharged. Thus, the whole process can repeat itself.

The ratio of C2 to C1 will determine the number of positive-going input pulses needed to accumulate the necessary threshold potential on C2. With C2 equal to C1, the frequency will be divided by a factor of 1. The higher the C2:C1 ratio, the more input pulses needed and, as a result, the greater the frequency division obtained. This circuit is sensitive to the magnitude of its input pulses, so keep the input amplitude at 9 volts, or thereabouts. Satisfactory performance with input signals as high as 10 kHz will be obtained with the parts listed.

PARTS LIST FOR FREQUENCY DIVIDER

C1—capacitor, .02-.1 uF (see text)
C2—.1 uF capacitor
D1,D2—1N914 silicon diode
D3—1N751A 5.1V, ½W zener diode
Q1—2N2646 unijunction transistor
Q2—2N3904 NPN transistor
R1—1,000-ohm resistor
R2, R3—220-ohm resistor
R4—1,500-ohm resistor
R5—22,000-ohm resistor



A VOM THERMOMETER

Almost all electronic components change characteristics as temperatures change. In the case of silicon diodes, like the 1N914, the characteristic that changes is the amount of *forward voltage drop.*

Diodes aren't perfect conductors, you see, because they must take advantage of the bias (voltage) across a semiconductor junction (the place where the two different kinds of semiconductor material, p and *n*, meet) in order to operate.

Almost every semiconductor device shows a junction voltage drop of about ½ Volt when forward biased, as the diodes here are.

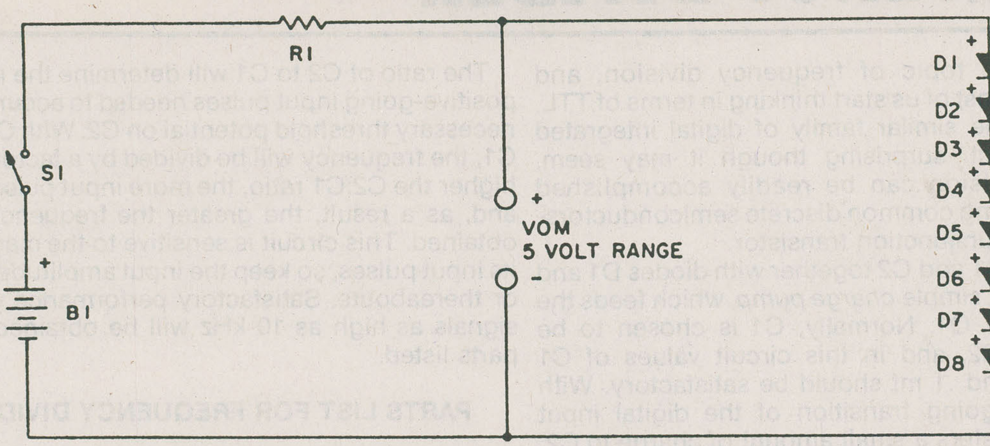
So if you string eight diodes in series, like these, and measure the voltage across the string on the 5 Volt scale of your VOM, you'll see the voltage varying up and down around 4 Volts as you change the temperature the diodes are exposed to.

You could calibrate a separate meter to give you actual degree readings, but for many purposes, just knowing the temperature is changing is enough.

PARTS LIST FOR A VOM THERMOMETER

B1—9 VDC battery
D1, D2, D3, D4, D5, D6, D7, D8, D9—Diode, 1N914 or equiv.
R1—4700-ohm resistor, ½-watt
S1—SPST switch

A VOM THERMOMETER



CAPACITANCE METER

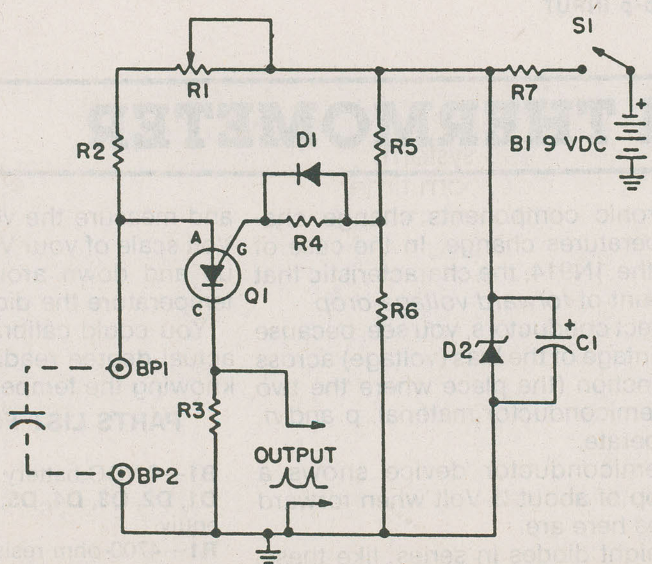
If you own a triggered-sweep oscilloscope or a frequency counter capable of making frequency measurements, you can use this PUT (programmable unijunction transistor) oscillator to measure capacitance. The practical range of measurement extends from 100-pF to about 10uF—wide enough to cover most of your measurements needs.

With an unknown capacitor connected across the binding posts, measure the time interval between output pulses on your scope or frequency counter. To convert time to capacitance, use the relationship:

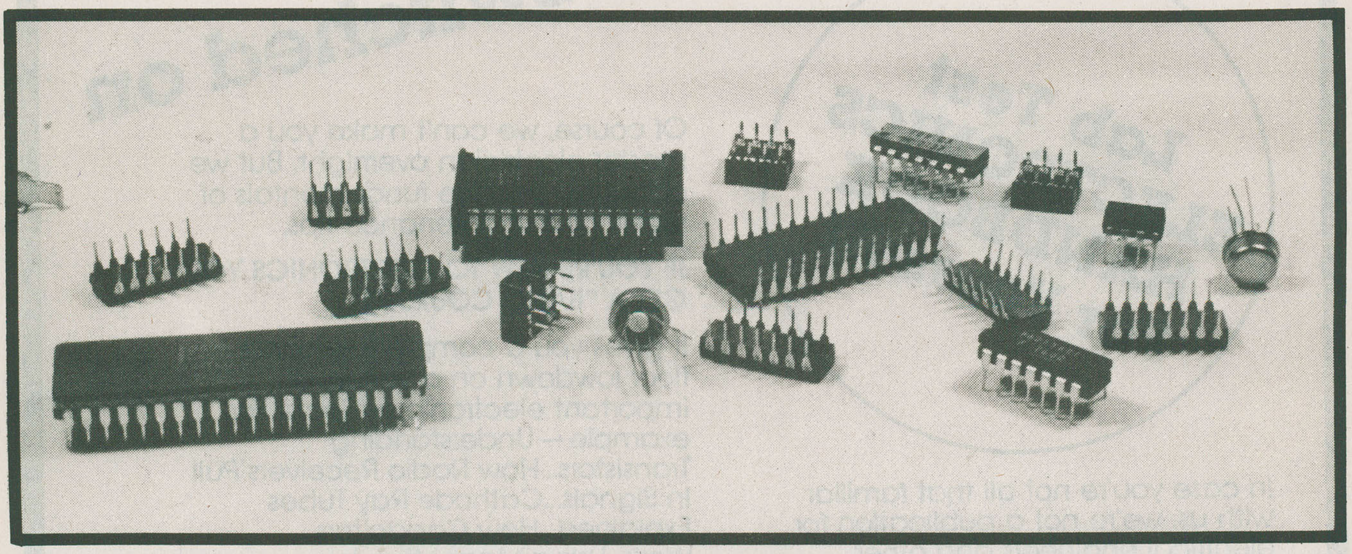
CAPACITANCE (uF) = 10 × TIME For instance, a reading of 100-microseconds (.0001-sec.) indicates a capacitance of .001-uF(or 100-pF). (NOTE 1-uF=1,000,000-pF). To calibrate the oscillator, hook a 1000-pF polystyrene capacitor across the binding posts and adjust R1 until the time between output pulses is exactly 100-microseconds.

PARTS LIST FOR CAPACITANCE METER

B—9volt transistor battery
BP1, BP2—binding posts
C1—100-uF, 10-VDC electrolytic capacitor
D1—1N914 diode
D2—1N752A, 5.6 volt, 1/2-watt zener diode
Q1—2N6027 programmable unijunction transistor
Note: All resistors rated 5% tolerance
R1—200,000-ohm trimmer potentiometer R2—390,000-ohms resistor
R3—22-ohms resistor
R4—1 Megohm resistor
R5, R6—2,200-ohms resistor
R7—560-ohms resistor
S1—SPST toggle switch



CHIP-BY-CHIP



THE GATING OF PULSES

By Ed Noll

Gating pulses on and off is an important facet in counting, switching, and other activities in digital circuits. The circuit arrangement of this column uses a clock generator and divider to form a low-frequency square-wave signal that will serve as a source of pulses that can be applied to one input of a NAND gate. How the logic applied to the second gate input affects the transfer of the pulses to the gate output can be shown. The LED demonstrates such action clearly because of the low repetition rate of the clock pulses. The same observations will be made using several other gates including AND, NOR and OR types.

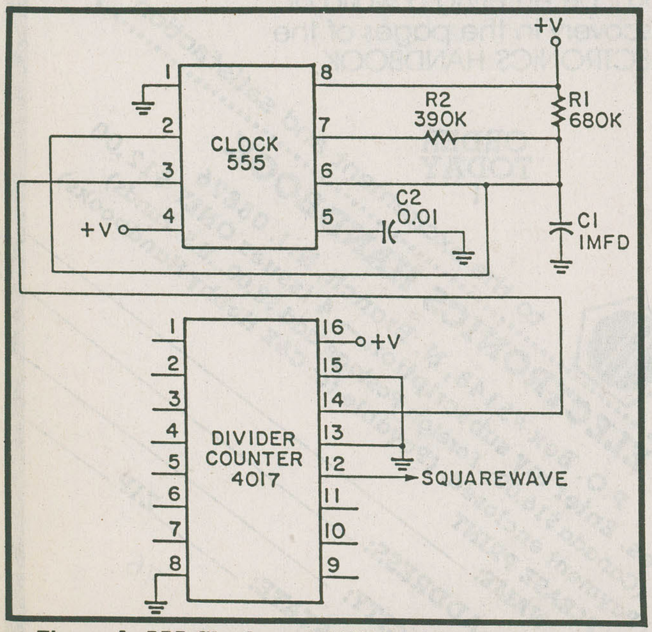


Figure 1. 555 Clock and 4017 Divider Generate the Pulse Train.

The schematic of the clock and divider pulse generator is given in Figure 1, in case you haven't built this basic unit for one of the previous columns. Capacitor C1 is used to set the clock frequency. The frequency desired is obtained by using a capacitor value of 1 uF for C1.

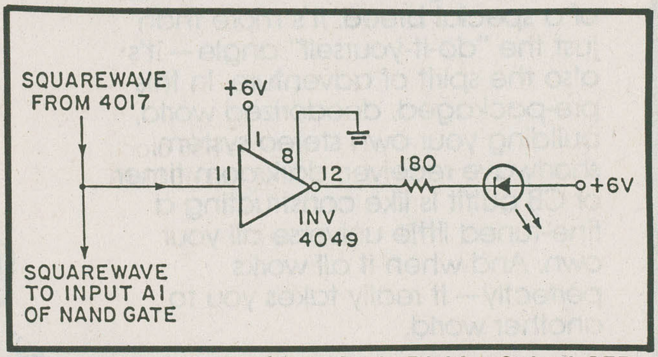


Figure 2. Addition of Inverter to Divider Output. LED is ON when Input is at logic 1.

The next step in assembling the demonstration circuit is to add a simple logic indicator at the output of the generator, Figure 2. This is one of the inverters in the 4049 inverter chip used in a previous column. The output LED of the converter is connected to illuminate when there is a logic 1 at the inverter input.

Connect this circuit to the clock output. Turn on the generator. Note the equal-length on and off periods of the generated square-wave pulse train. This is the pulse train that will be applied to the NAND gate to observe its operation.

The NAND gate is a quad 4011 which we used in a previous column, in the Spring 1988 issue of Electronics Handbook. Next wire the single NAND gate and follow it with a logic probe comprised of two more of the 4049 inverters. The complete circuit is described in Figure 3. The logic probe circuit is the same as the one you may have built for use in the demonstration circuit of the previous column.

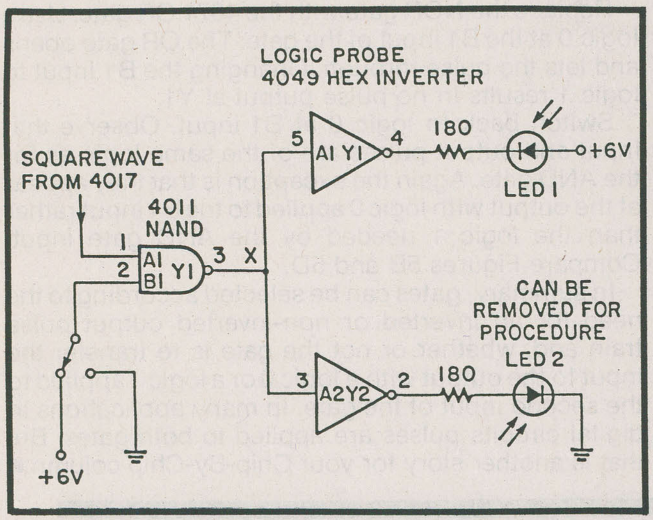


Figure 3. NAND Gate Circuit Followed by Logic Probe. Use only LED 1 leg.

In the operation of the logic probe when the Y1 output of the NAND gate is logic 1, LED 1 will go on. If the Y1 output is logic 0, LED 2 would normally go on. In this demonstration circuit, however, the LED 2 side of the circuit is not needed. Consequently, you can remove LED 2 from the circuit to avoid any confusion.

The output of the pulse generator is applied to the NAND gate input A1. A wire lead is connected to NAND gate input B1. This lead is used to connect either a logic 1 (+6 volts) or a logic 0 (GND) to NAND gate input B1 when checking out gate operation with the pulse train from the generator applied to gate input A1. The four chips used in the demonstration circuit are shown photographically in Figure 4. Starting from the top, they are the 555 clock, the 4017 counter, the 4049 inverter, and the 4011 NAND gate chips.

Observing NAND Gate Operation

Turn on the generator. When you do so, you will notice the generator output indicator LED will flash on and off, showing that the clock generator is working and is being applied to the NAND gate input A1. Next switch the NAND input gate B1 to logic 1 by inserting the associated lead at a +6 volt point. By so doing the gate is switched on and the pulse train passes to the gate output Y1 as proven by the flashing of LED 1 of the logic probe. Switch the NAND input gate B1 to logic 0. Now the gate is switched off and no pulse train passes to the output.

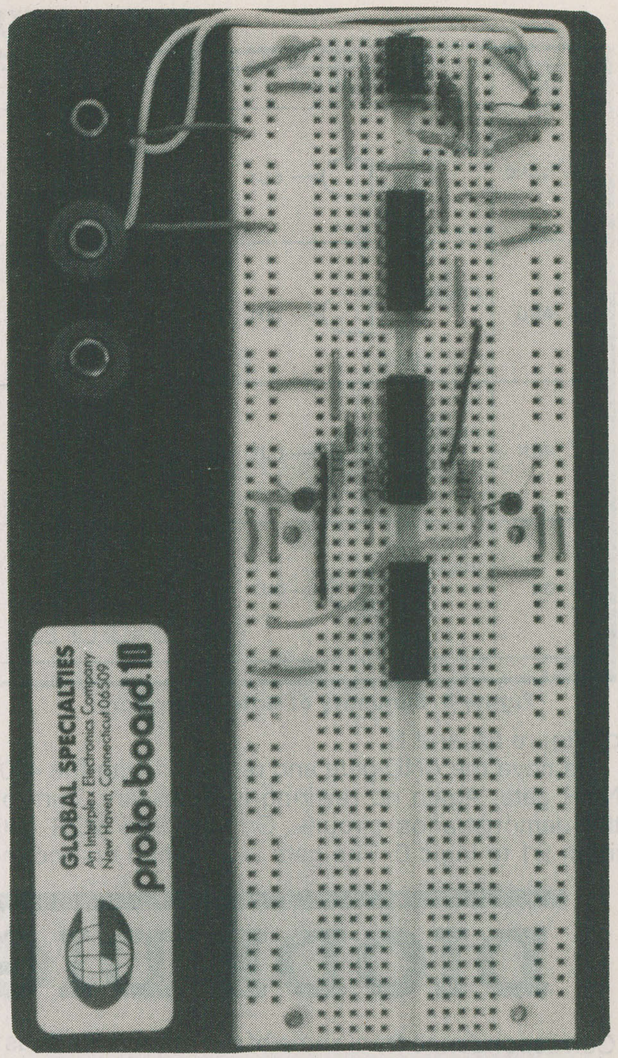


Figure 4. Components mounted on Solderless Circuit Board.

Change gate input B1 back to logic 1 to switch the gate on once again. Observe the phasing of the gate input and output pulse train. When the input pulse is positive the output pulse is negative. Stated another way, the switched on NAND gate inverts the pulse train, Figure 5A. Keep this in mind as you check out some of the other gates.

Observing AND, NOR and OR Gate Operations

Replace the 4011 NAND gate with a 4081 AND gate. Gate wiring is identical and the changeover can be done without any rewiring of the circuit board. Just remove the 4011 and replace it with the 4081. Turn on the generator again. Switch the AND input gate B1 to logic 1. The AND gate closes and the pulse train appears at the gate output. Switch the AND input gate B1 to logic 0 and the pulse train does not appear at the gate output.

Go back to logic 1 at input B1. Observe the different phasing of the input and output pulse train. When the input pulse is positive the output pulse is positive too. The two LED's turn on and off at the same time indicating that the input and output pulses have the same logic phasing, just the opposite of the NAND

THE GATING OF PULSES

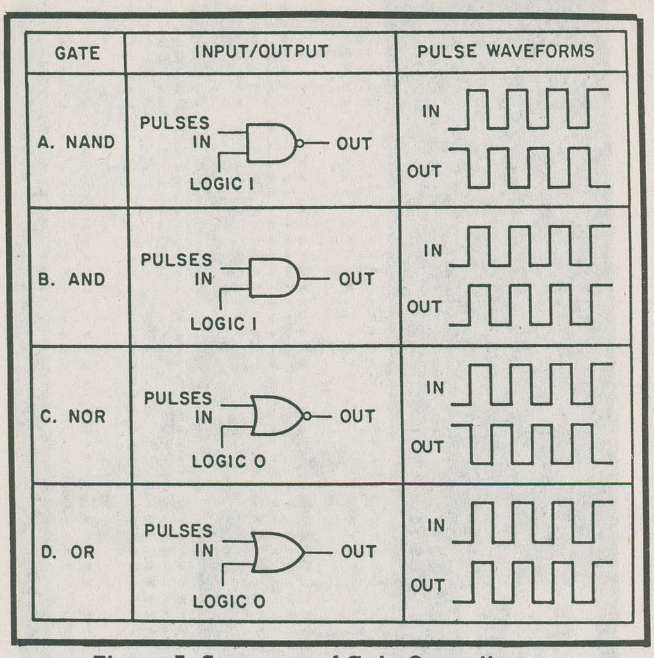


Figure 5. Summary of Gate Operation.

of Figure 5A and B.

Remove the AND gate and replace it with the 4001 NOR gate. Again no rewiring is necessary. Turn on the demonstration circuits. Connect the NOR gate input B1 to logic 0. The gate is switched on and the gate operation. Refer to the pulse waveform drawings pulses appear at the Y1 output. Connect the NOR gate input at logic 1. Pulses do not appear at the output.

Change the B1 input back to logic 0. Observe that the NOR gate output is inverted as compared to the generator pulses applied to the NOR gate input A1. The same situation existed for the NAND gate operation. However there is one difference. NOR gate *on* operation occurs when the input B1 is logic 0 rather than the logic 1 of NAND gate operation. Compare Figure 5A and 5C.

Replace the NOR gate with the 4071 OR gate. Use a logic 0 at the B1 input of the gate. The OR gate opens and lets the pulse through. Changing the B1 input to logic 1 results in no pulse putput at Y1.

Switch back to logic 0 at B1 input. Observe that input and output pulses are of the same logic as for the AND gate. Again the exception is that they appear at the output with logic 0 applied to the B1 input rather than the logic 1 needed by the AND gate input. Compare Figures 5B and 5D.

In summary, gates can be selected according to the need for an inverted or non-inverted output pulse train and, whether or not the gate is to transfer the input to the output with a logic 0 or a logic 1 applied to the second input of the gate. In many applications in digital circuits pulses are applied to both gates. But that is another story for your Chip-By-Chip column.■

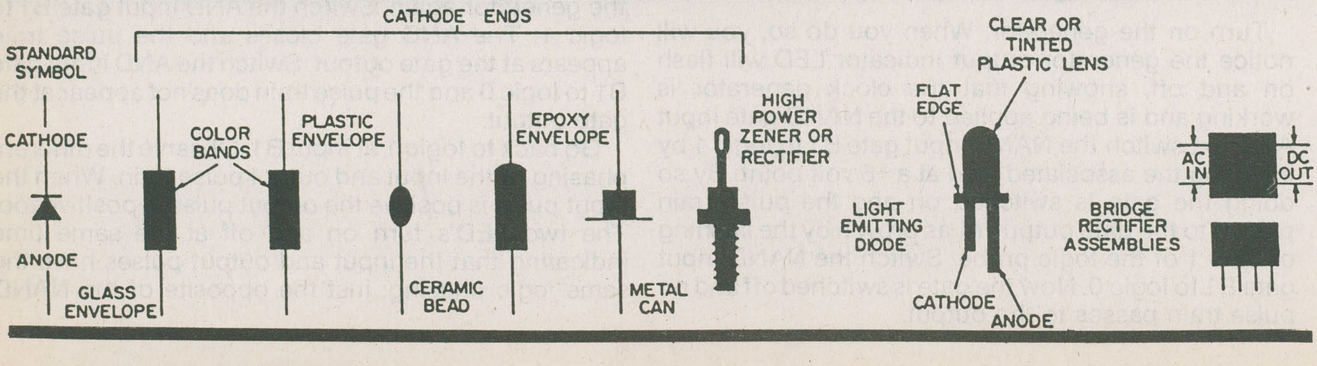
DIODE DIGEST CHART

Correspondence from some of our readers leads us to believe that there is considerable confusion among readers who have only recently joined the ranks of the "Electronics Hobbyists" concerning the identification and/or value of some of the more common diodes. For example, the following letter, recently received from a reader, pretty well sums it up:

"I have been trying for several months to purchase a power supply that I can use to power a walkie-talkie from house current. I've finally given up and decided to build my own. I have a transformer that converts 110 VAC to 12.6 VAC, some large filter capacitors salvaged from a discarded television set and some 'bargain bag' diodes I purchased from a discount store. The diodes are black, unmarked, and have one rounded end. Can I use them, or will I have to invest in new ones with known values?"

Of course, we couldn't be sure exactly what the reader had in this supply of diodes, but from the description, and our reference to the above chart, we were fairly certain that he had a supply of epoxy-encapsulated rectifiers with somewhere between 100 to 200-PIV rating. These would easily fill his needs if our guess was right. Although we haven't heard anything further from this reader, we assume that he didn't blow himself up.

For those readers who have similar difficulty with diodes, we suggest that you keep a copy of this chart handy on your workbench or in your spare parts "junkbox" as a reference for identifying the leads and types of whatever diodes happen to find their way into your possession. ■



RANDOM RHYTHM MACHINE

By C. R. Fischer

Rhythm is a mainstay in the language of music. It adds essence and drive to the melody and harmony, and brings momentum to the groove. It's no surprise that drums were the first instrument invented by mankind.

For those looking to explore the twists and turns of rhythm, adding a randomizing process can create new patterns that a musician would not think of on his or her own. But playing with random music is a narrow tightrope: not enough chaos and your rhythms will be simple and cloying; too random, and the music will become anarchy.

What is needed is a process that allows control between the static and the random. This allows the user to determine the final results. And by using simple digital logic, we can put together a complex pseudo-random rhythm generator at a very reasonable cost. It includes 3 simple drum sound generators, so you can hear the results with any hi-fi or audio amplifier. If you already have some synthesizers sitting around, these can be triggered directly from the "Random Rhythm" for a variety of catchy new effects.

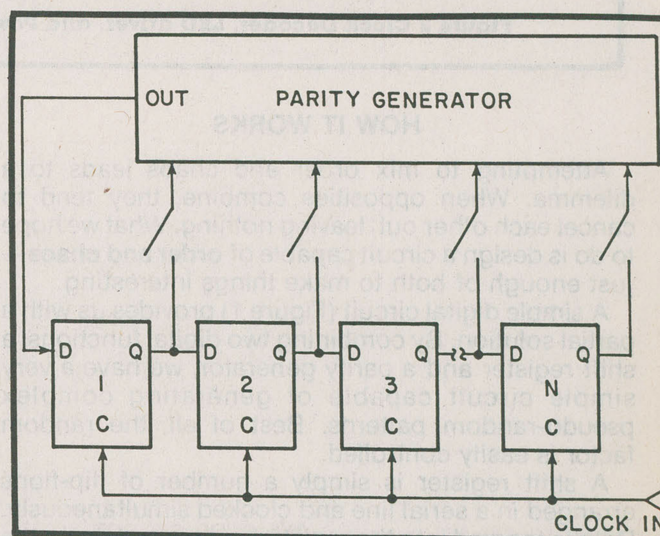
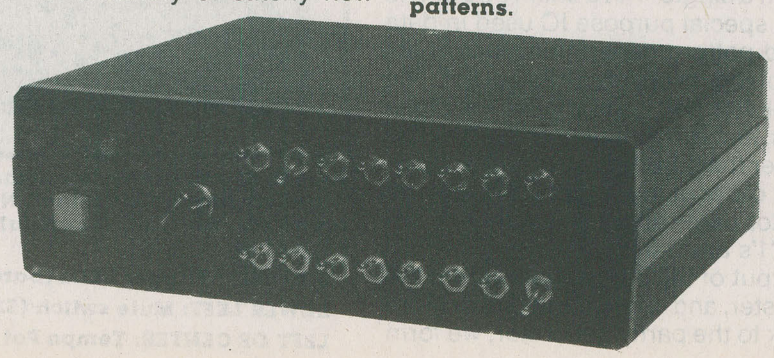


Figure 1 Combining two simple digital circuits, a shift register and a parity generator, gives us a circuit capable of generating a wide variety of complex patterns.



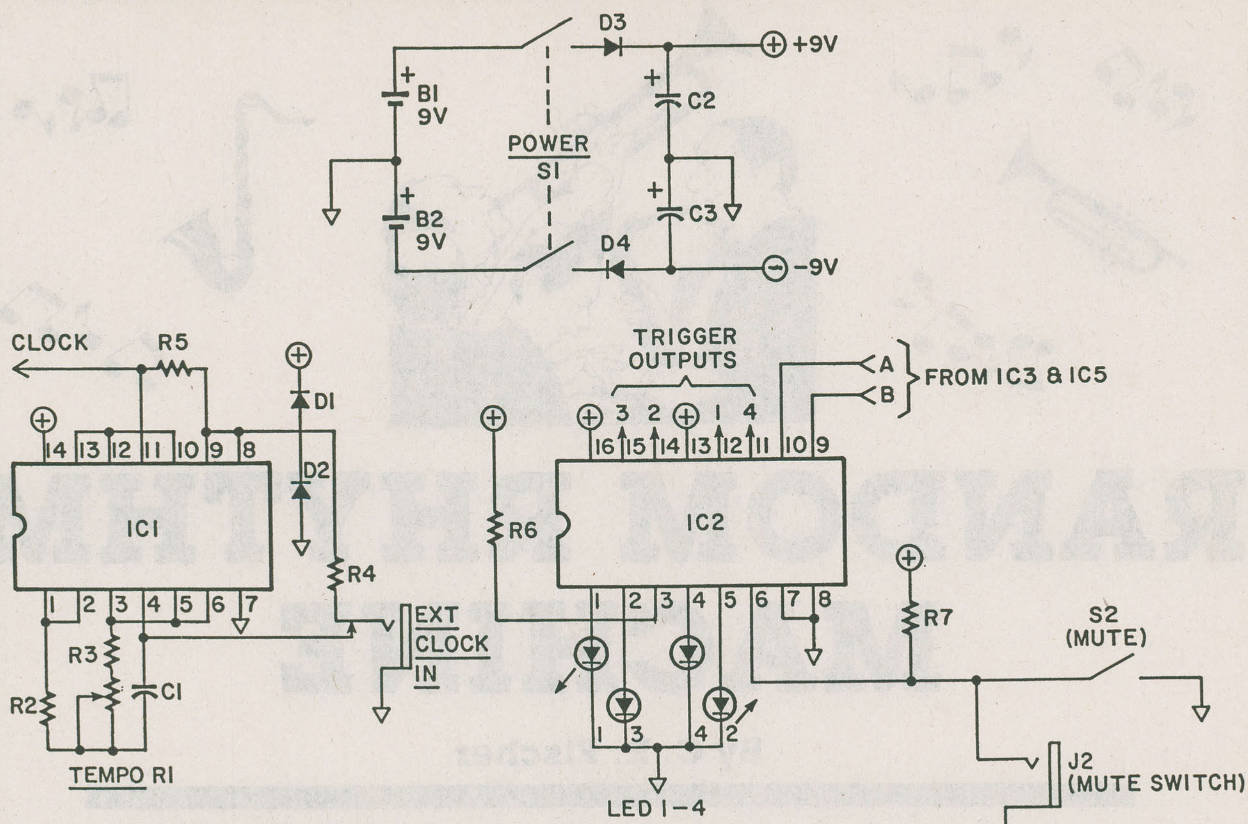


Figure 2 Clock Decoder, LED driver, and Power Supply schematics.

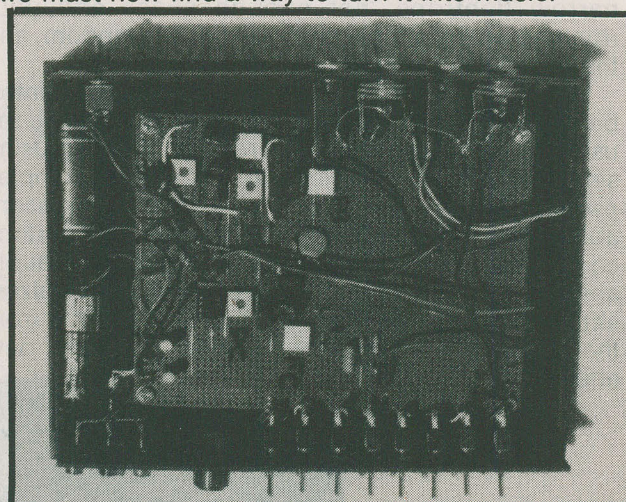
HOW IT WORKS

Attempting to mix order and chaos leads to a dilemma. When opposities combine, they tend to cancel each other out, leaving nothing. What we hope to do is design a circuit capable of **order and chaos**—just enough of both to make things interesting.

A simple digital circuit (Figure 1) provides us with a partial solution. By combining two digital functions, a shift register and a parity generator, we have a very simple circuit capable of generating complex pseudo-random patterns. Best of all, the random factor is easily controlled.

A shift register is simply a number of flip-flops arranged in a serial line and clocked simultaneously. Data is toggled into the register and passed down the line from one flip-flop to the next. A register, 4 flip-flops long, will provide a pattern of '0001', '0010', '0100', and '1000' from a single '1' in a chain of '0's. The parity generator is a special purpose IC used in data communications and pattern generation. It consists of a certain number of inputs and a single output. The parity generator looks at the combination of highs and lows at its inputs, and the output goes high or low depending on whether the number of highs are odd or even. The number or order of inputs are unimportant; all the parity generator cares about is whether or not the total number of '1's are odd or even.

By feeding the output of the parity generator to the input of the shift register, and connecting one or more register outputs back to the parity generator, we form a loop capable of generating complex feedback patterns. A single connection will provide a simple, repetitive sequence. Two or more paths create complex sequences, with each additional path increasing the complexity. Now that we've found a way of creating complex pseudo-random patterns, we must now find a way to turn it into music.



Here is an excellent view of the internal layout of the "Random Rhythm Machine". Note that there is ample room for all parts carefully arranged on the perfboard.

TOP LEFT: Trigger LEDs (barely visible)

LOWER LEFT: Mute switch (S2)

LEFT OF CENTER: Tempo Pot (R1)

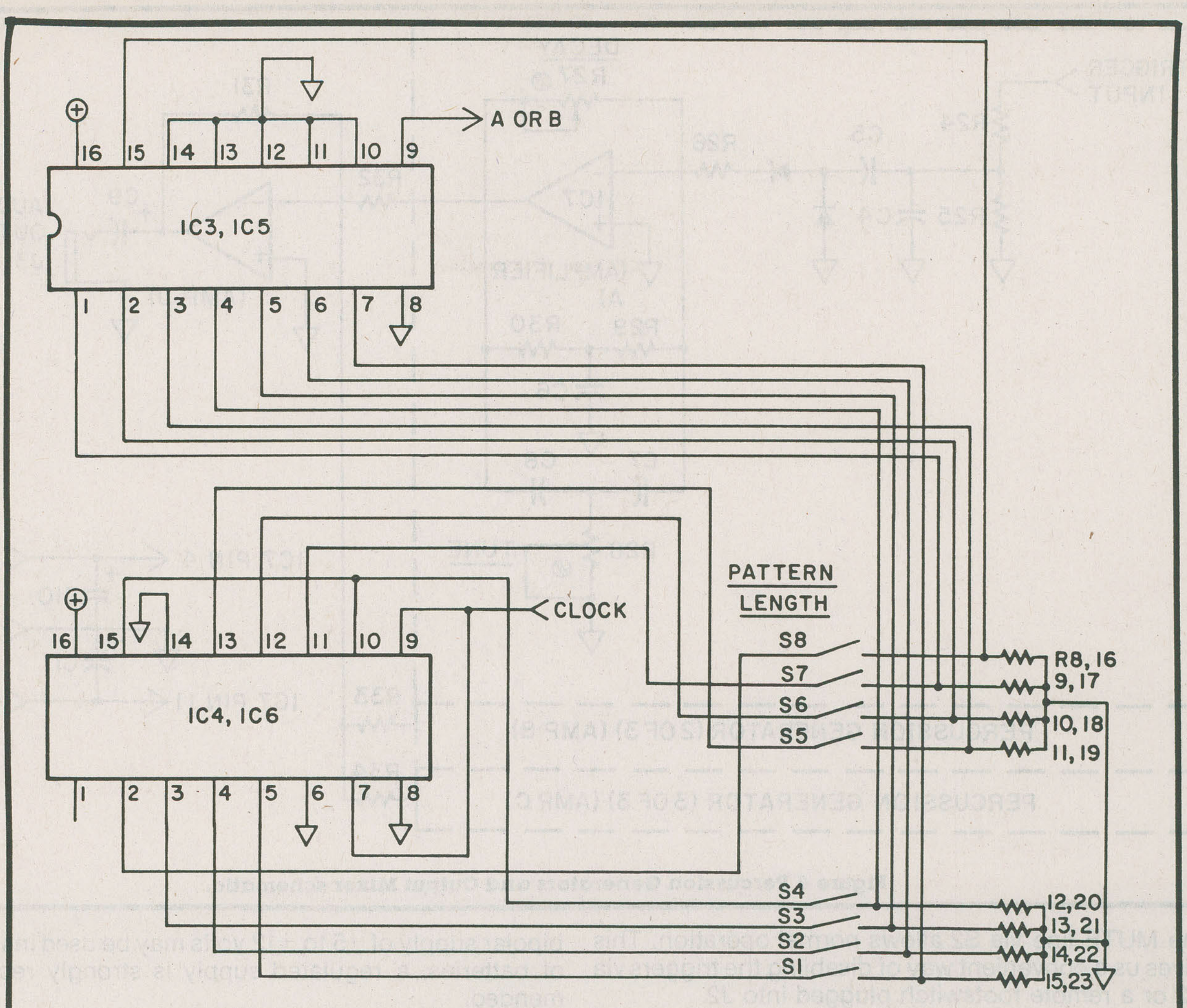
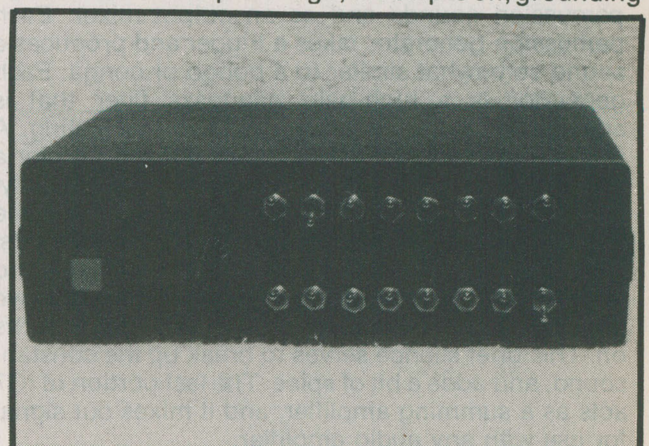


Figure 3 Pattern Generators (Build Two).

In the Random Rhythm Generator, we combine two independent register/parity circuits with a common clock to provide 4 trigger outputs. In the schematic (Figure 2), IC1 generates our master clock with R1 giving us control of the tempo. J1 allows us to use an external clock for synchronization purposes; it should be a 6 to 10V square wave. R4, D1, and D2 protect the circuit from excessive input levels; the top half of the IC adds hysterisis to clean up "sloppy" or "noisy" clock sources.

The pattern generators are illustrated in Figure 2. Note that there are two, each with independent outputs and switches. ICs 4 and 6 are the shift registers; ICs 3 and 5 are the parity generators. R8-23 are 'pull-down' resistors that force the parity generator inputs to ground when the switches are opened, and may be any value between 100k and 1 Megohm without problems. The switches allow various combinations of shift register outputs to be fed into the parity generator, which gives us a tremendous number of possible patterns.

IC2 (Figure 2) is a dual 1-of-4 analog switch that decodes the two pattern generators into usable triggers. The binary pattern at pins 9 and 10 of the chip determine which switches are closed; this gives us 4 possible output states. Since the IC is a dual device, we use the top half to generate triggers and the lower half to turn on several LEDS to show us what the Random Rhythm is doing visually. In addition, pin 6 of the CD 4052 gives us a master control of the circuit. When the pin is high, the chip is off; grounding



Front view of the "Random Rhythm Machine" demonstrates the neatness of the author's finished project.
The two rows of toggle switches are S3-20: (Top row for one parity circuit and Bottom row is for the other).

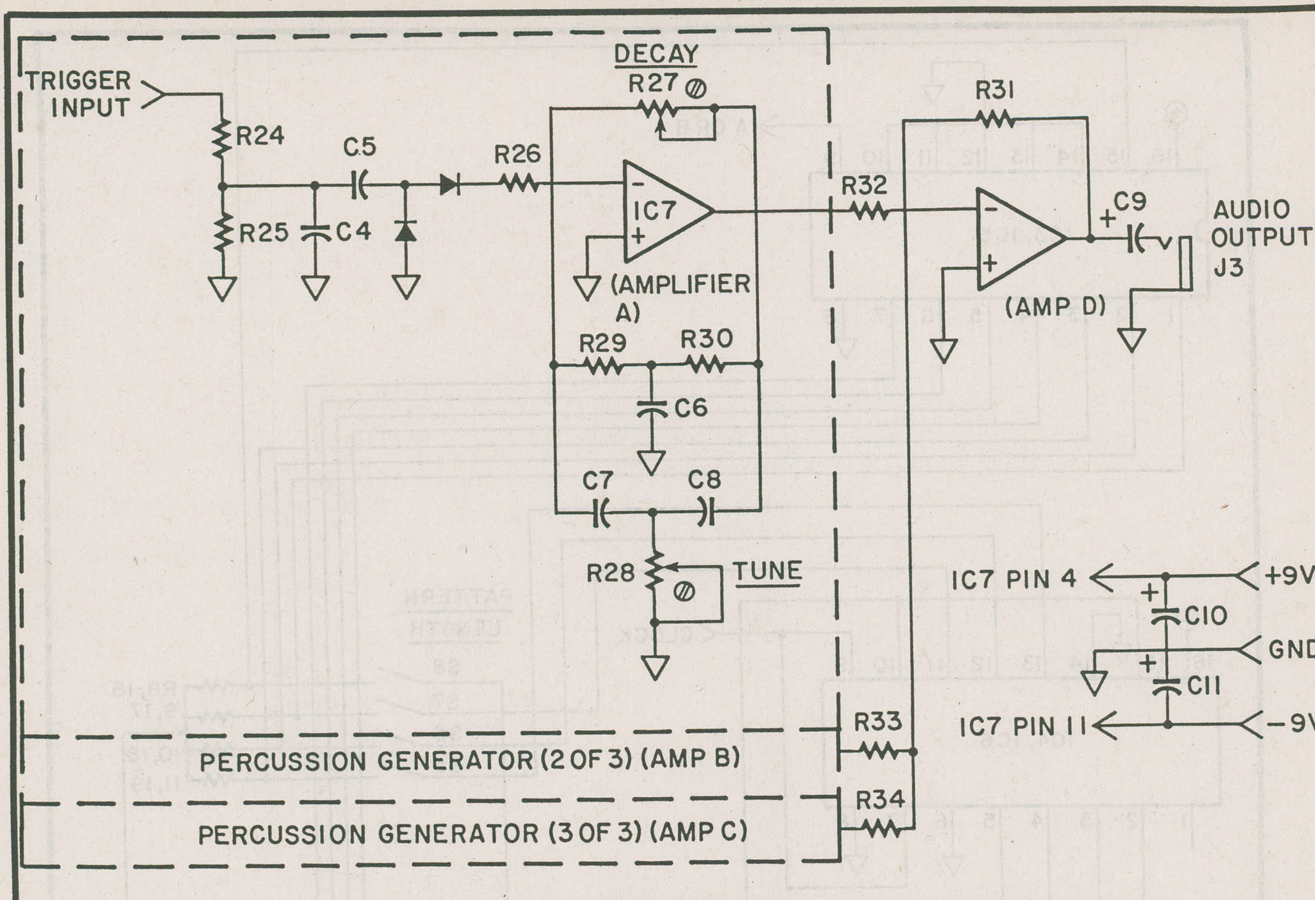


Figure 4 Percussion Generators and Output Mixer schematic.

the MUTE line via S2 allows normal operation. This gives us a convenient way of disabling the triggers via S2 or a remote footswitch plugged into J2.

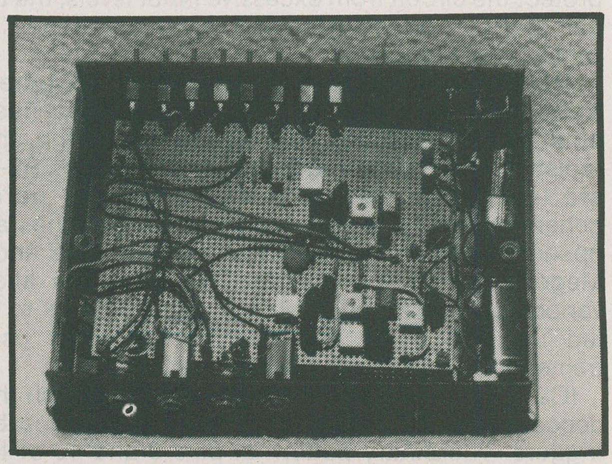
So we now have 4 triggers for use. If you've got some sound generators or synthesizers sitting around, you can look them up directly; for the rest of us, we need something to make musical sense of the thing.

Figure 4 consists of the sound generating portion of our circuit. A quad op amp (IC7) is used to generate 3 percussion sounds and as an output mixer. Each percussion generator takes a trigger and produces a sound somewhat similar to a bongo or conga. Each generator is a high-gain bandpass filter that is adjusted so that it is on the brink of oscillating. A trigger pulse causes the resonant filter to ring for a short period, giving us a percussive sound quality. R28 adjusts the drum's tuning, while R27 controls the decay, which gives us a variety of percussive sounds. Note that there are 4 triggers and only 3 sound generators. By leaving one trigger unused, we generate a 'rest' whenever the unused trigger turns on. This brief silence serves to break up the constant sound, and adds a bit of spice. The last portion of IC7 acts as a summing amplifier, and it mixes our signal for use with any audio amplifier.

By using CMOS ICs in our design, we have the advantage of being able to power the circuit from two 9-Volt batteries. S1 is the power switch; D3 and D4 prevent reverse polarity from wreaking havoc on our circuit. C2 and C3 are supply bypass capacitors. A bipolar supply of ±5 to ±12 volts may be used instead of batteries; a regulated supply is strongly recommended.

BUILDING IT

The Random Rhythm Generator uses a non-critical layout, and it may be built using any of the usual wirewrap or perfboard techniques. The author's prototype used 2 4½"×6" perfboards; the digital electronics (Figures 2 and 3) were on the bottom, with the analog electronics and trimpots mounted on the top for easy access.



Another view of the internal layout. A place for everything and everything in its place.

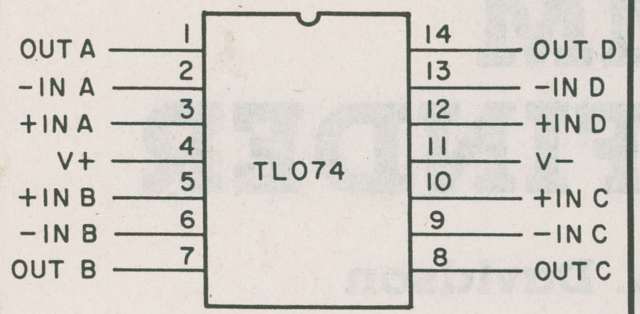


Figure 5 Pinout of IC7.

The repetitive circuitry between the 16 panel switches and the boards allow a lot of room for error, so some caution is called for. Ribbon cable would be a good idea here. If you're really on a budget, you might consider using DIP switches to economize (2 DIP switches run at around $ 3.50; 16 toggle switches might run at a buck or two each). Virtually any metal or plastic case may be used for the circuit.

IC sockets are strongly advised for all chips. All ICs except IC7 use CMOS technology, and are susceptible to static discharge. Avoid handling the ICs until all wiring is complete, and follow the usual guidelines. After the chips are safely installed, set all tune trimpots to midway, and all decay trimmers to minimum resistance. Connect J3 to an audio amplifier, and double check that the amplifiers volume is *completely down.* If one of the percussion generators is miswired or misbehaving, it could oscillate at full volume—which could damage your speakers, your hearing, or your sanity!

TEST AND CALIBRATION

Connect a pair of batteries to the circuit, and apply power via S1. One or more of the LEDS should turn on. If not, try S2 and see if they come on. If this has no effect, turn off the power and examine the circuit for wiring problems. Once the LEDs are working, adjust R1 and verify that the speed of the LED flashing varies.

Now it's time to raise the volume on your amplifier and listen for sounds. If you hear one or more constant tones, the sound generators are oscillating. Change the settings on the decay trimmers until this stops. Close a switch on both pattern generators and slowly raise the decay pot on a generator. The sound quality should go from silence, to muted, till it finally breaks into oscillation. Set the pot for a pleasing sound, then adjust the tuning trimmer and observe the effect. Note that there is some interaction between the two trimmers and you may have to spend a little time obtaining a pleasing sound quality. Then go on to the other two generators and duplicate the procedure. Your Random Rhythm is now complete and ready for use.

Now experiment with the switch settings. Try closing the number 4 switch for one pattern generator, and the number 8 for the other. You should hear a simple, repeating sequence (this is because 4 and 8 are multiples of 4/4 time). Now close any other switch; the pattern should suddenly become irregular. A few minutes with the Random Rhythm will provide plenty of unusual patterns.

While the Random Rhythm is fun by itself, it can be paired with any rhythm box with a clock output for a variety of special effects. While the rhythm box provides a regular beat, the Random Rhythm adds 'fills' and variations around the basic rhythm. In addition, a footswitch may be used with J2 to turn the rhythm on and off as desired.

Order and chaos make for an unusual pair, but the results can be useful, as well as unpredictable. Build the Random Rhythm and add a little fun (and chaos) to your music. ■

PARTS LIST FOR RANDOM RHYTHM GENERATOR

SEMICONDUCTORS
IC 1—CD 4001B (Quad CMOS NOR gate)
IC 2—CD 4052B (Dual 1-of-4 multiplexer)
IC 3,5—CD 4531B (12 input parity generator)
IC 4,6—CD 4015B (dual 4-stage shift register)
IC 7—TL 074 (Quad low-noise op amp)
LED 1—4 Inexpensive LEDs
D1, 2, 5, 6—1N914 diodes
D3,4—1N 4001 rectifiers
S1—DPDT slide/toggle switch
S2—SPST pushbutton or toggle switch
S3-20—SPST slide, toggle, or DIP switch assembly
B1,2—9 V transistor radio batteries
Capacitors—(all rated at 25V or better)
C1—.5 uF poly or film cap
C2, C3—10 uF electrolytic or tantalum
C4, 6,7,8—(12 total) .1 uF film or poly
C9,10,11—1 uF electrolytic or tantalum
C5—.005 uF disc (3 total)
Resistors—(¼W or greater)
R1—1 Megohm pot
R2,5—1 Meg
R3,—32,33,34,(31) 10K
R4—100K
R6—1K
R7—33K
R8-23—100K to 1 Meg (exact value not important)
R24—1K (3 total)
R25—39K (3 total)
R26—330K (3 total)
R27—200K trimpot (3 total)
R28—2K trimpot (3 total)
R29,30—100K (6 total)
Misc.—Perfboard, IC sockets, (3) ¼" phone jacks, (2) 9V battery clips, solder, mounting hardware, knob for R1, etc.

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DMM FAULT-FINDER

By Homer L. Davidson

How many times have have you finished the last connection on your electronic project, fired it up and nothing happens? Yes, the switch is on, still nothing works. What did I do wrong? What do I do now?

Has this ever happened to you? You're mighty lucky if it hasn't happened with at least one of your projects. To many of us, who enjoy building electronic projects, it's downright discouraging. You begin to wonder if you can wire anything anymore.

Sometimes you want to throw the project in a corner or against the wall and forget it. Other times you just let it lie and hope that the next time you hook it up, by some miracle, it will work. Of course it never does and you keep remembering the dollars you have already invested in this project. Why not carefully dig in and see what went wrong...just one more time?

Maybe you made a bad solder connection. Sometimes when you're in a hurry, you can miss soldering one little old wire. Maybe one of the components is defective. It couldn't happen to you. Don't bet on it. It happens all the time...to the best of us. Just because that component or part is new, doesn't mean it can't fail before it is placed in action. OK! let's take a few measurements with that new digital multimeter you received for your birthday or Christmas and see how it works (Figure 1).

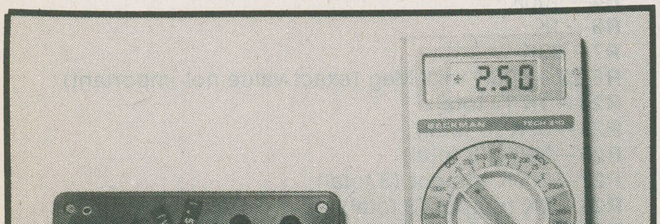


Figure 1: A digital multimeter (DMM) is the ideal test instrument to check out your project when it fails to operate.

Which Meter To Use?

There are many inexpensive digital multimeters (DMM's) to choose from with costs ranging from $29.95 to $79.95. Most meters accurately measure voltage current, and resistance. Several have autoranging and audible continuity features. Others check capacitance, transistors, diodes and even temperature. Besides accurate voltage and resistance measurements, it is recommended that you choose a DMM with transistor and diode testing capacity.

Small resistance and low voltage measurements are needed in checking out solid-state circuits. Very low voltage measurement of the transistors forward bias, between the base and emitter terminals, is a must. Measuring resistance measurements under one ohm may help locate a burned or open emitter bias resistor. Locating the open or leaky transistor or diode with a diode-transistor test is needed in checking out those solid-state projects.

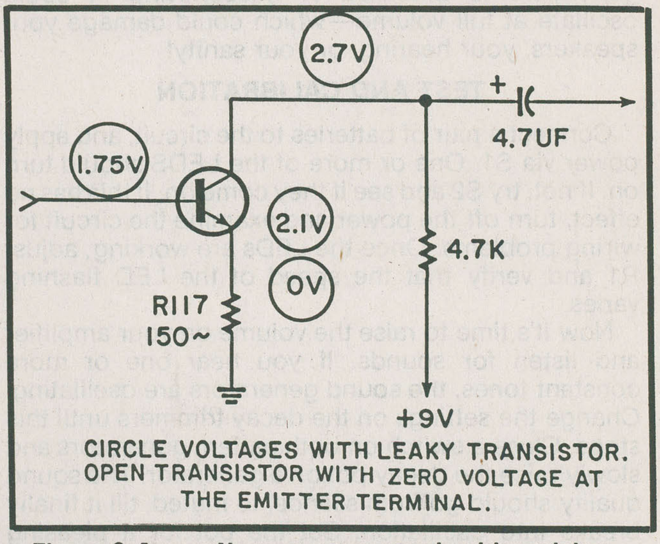


Figure 2: Low voltage measurements at transistor terminals may indicate a leaky transistor or improper supply voltage. Zero voltage at the emitter terminal indicates the transistor or emitter resistor is open.

Critical Voltage Measurements

Accurate voltage measurements at the terminals of a transistor or IC component may determine if the part is open or leaky (Figure 2). Very low voltage measurement at the collector terminal of a transistor or voltage supply terminal of a suspected IC may

indicate the component is leaky. Likewise, very low voltage at all terminals of a transistor indicates the transistor is leaky. Higher-than-normal voltage at the collector terminal and no voltage at the emitter terminal indicates that the transistor is open. No voltage at the emitter terminal will result from a open emitter resistor.

The suspected transistor may be tested with low bias voltage measurements between the base and the emitter terminals. An NPN transistor has a forward bias of .6 volts. You can expect a .3 volt bias with a PNP transistor. You will note that most schematics indicate these bias voltage differences between the two elements. If no bias voltage is found, you may assume that the transistor is leaky or open. When the bias voltage is much higher than normal, the transistor is usually open or has a high resistance junction between the two elements.

Critical voltage measurements within the circuit often indicates a leaky component, defective power supply circuits or a weak battery. Check the battery after removing it from the circuit. Very low voltage at the supply pin of a suspected IC may indicate a leaky IC or a defective power source.

Accurate Resistance Measurements

Correct resistance measurements in solid-state circuits will show if a component is open or leaky. Improper wiring connections will usually show up with accurate resistance measurements. A small coil, transformer winding or low-ohm resistor will often open with ohmmeter continuity tests. Leaky transistors or ICs can usually be located with accurate resistance measurements.

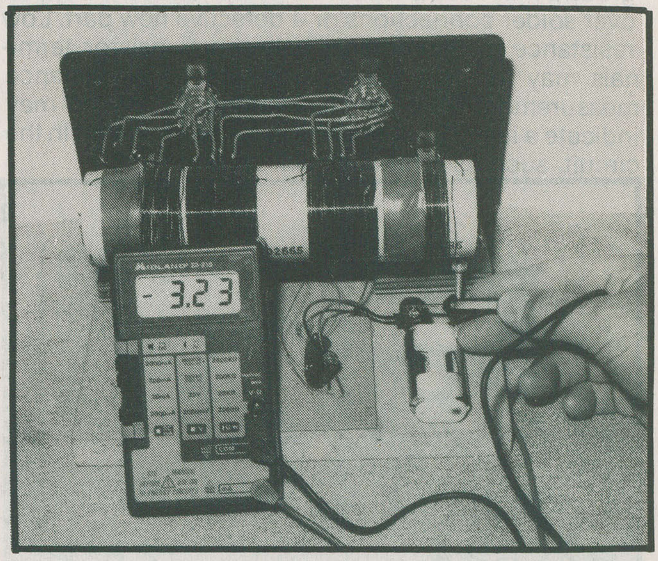


Figure 3: Take accurate current measurements when the batteries last for only a few hours or the battery voltage is low. Remove one end of the battery to take measurements.

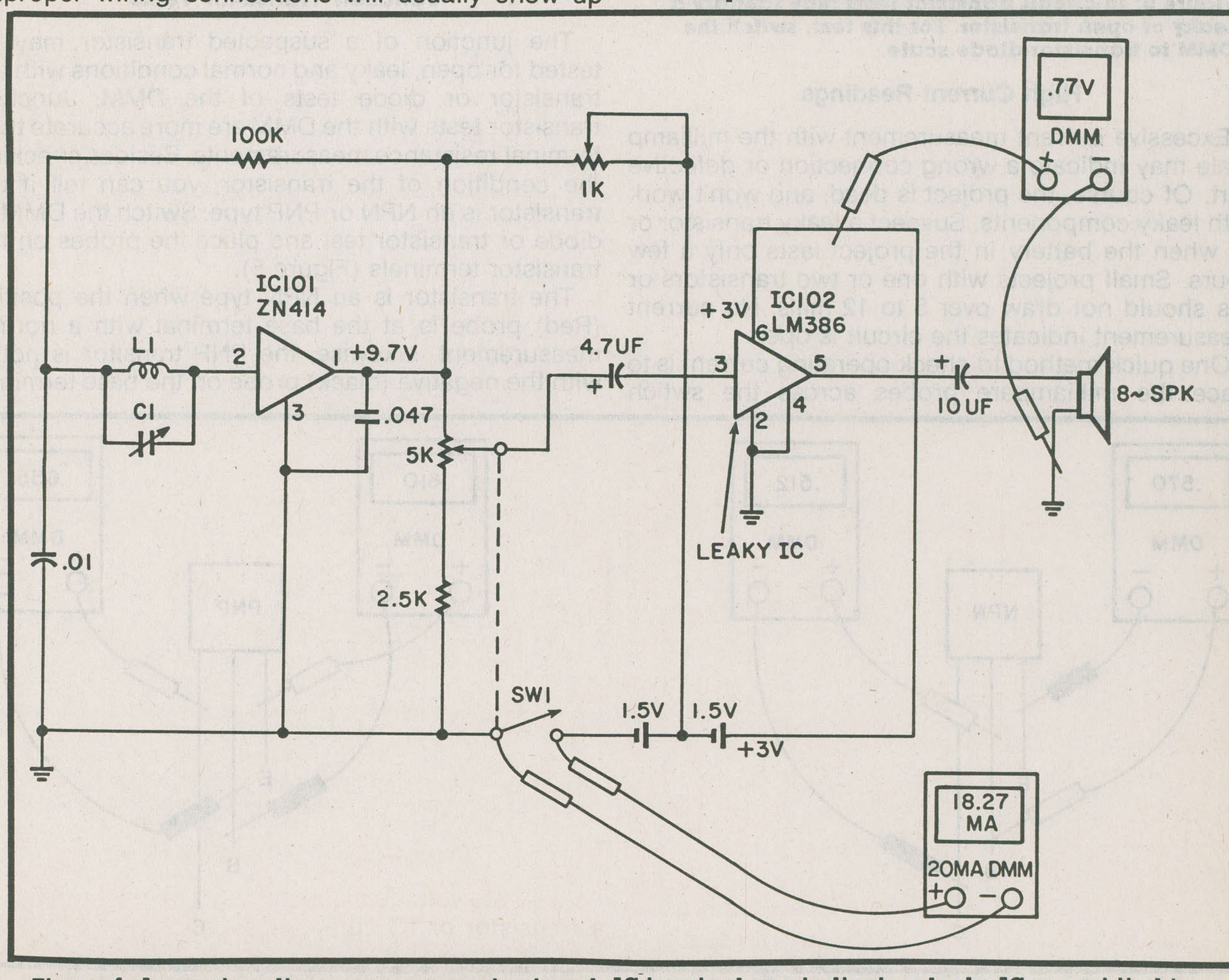


Figure 4: Accurate voltage measurements at each IC terminal can indicate a leaky IC or part tied to it. Disconnect the suspected leaky pin and take low resistance measurements to ground.

When checking out defective audio output circuits, critical resistance measurements will generally locate a defective component. After replacing the component, accurate resistance measurements to chassis ground may locate a poor soldered junction, slopped over solder connections or a defective new part. Low resistance measurements between transistor terminals may locate a leaky transistor. Low resistance measurement from one IC terminal to ground may indicate a leaky IC or a low resistant component in the circuit. such as a resistor, coil or diode.

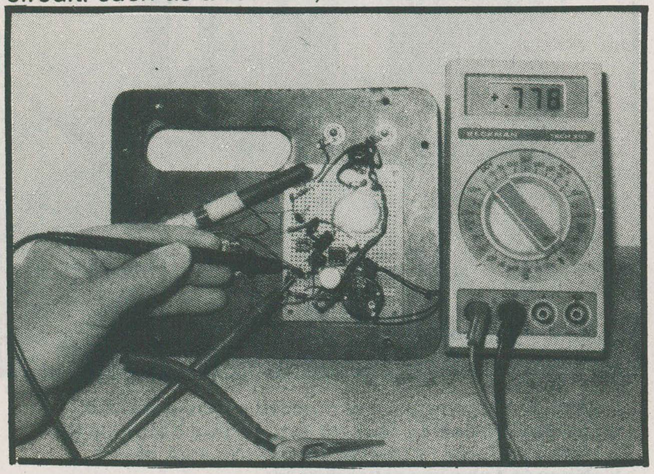


Figure 5: In-circuit transistor tests may identify a leaky or open transistor. For this test, switch the DMM to transistor-diode scale.

High Current Readings

Excessive current measurement with the milliamp scale may indicate a wrong connection or defective part. Of course, the project is dead, and won't work with leaky components. Suspect a leaky transistor or IC when the battery in the project lasts only a few hours. Small projects with one or two transistors or ICs should not draw over 5 to 12 mills. No current measurement indicates the circuit is open.

One quick method to check operating current is to place the milliampere probes across the swtich terminals with the switch turned off. Now read the total operating current. If the switch terminals are difficult to get at, or there's no switch in the circuit, insert the milliamp meter probes in series with the batteries or power supply source. Simply rotate the battery terminals on the 9 volt battery 180°, with one terminal connected and take a current measurement between battery terminal and battery plug (Figure 3). Place a thin piece of cardboard between the batteries and place the meter probes on the front and the back terminals of the batteries (on each side of the cardboard). Remember, when taking current measurements, place the meter probes in series with the voltage source.

Suspect an open circuit or improper voltage source if you got a no-current measurement. Check for a poor switch contact, disconnected wires or a dead battery or power supply. First, measure the voltage applied to the circuit. Often higher voltage will be measured with little or no current flow. Very low voltage may indicate a leaky component pulling heavy current. (Figure 4). Cut the wire or foil feeding the suspected transistor or IC, when more than one is in the schematic, to isolate the leaky component. Place the current meter leads across each end of the cut wire or foil to accurately measure the working current.

Junction Transistor Tests

The junction of a suspected transistor may be tested for open, leaky and normal conditions with the transistor or diode tests of the DMM. Junction transistor tests with the DMM are more accurate than terminal resistance measurements. Besides checking the condition of the transistor, you can tell if the transistor is an NPN or PNP type. Switch the DMM to diode or transistor test and place the probes on the transistor terminals (Figure 5).

The transistor is an NPN type when the positive (Red) probe is at the base terminal with a normal measurement. Likewise, the PNP transitor is noted with the negative (black) probe on the base terminal.

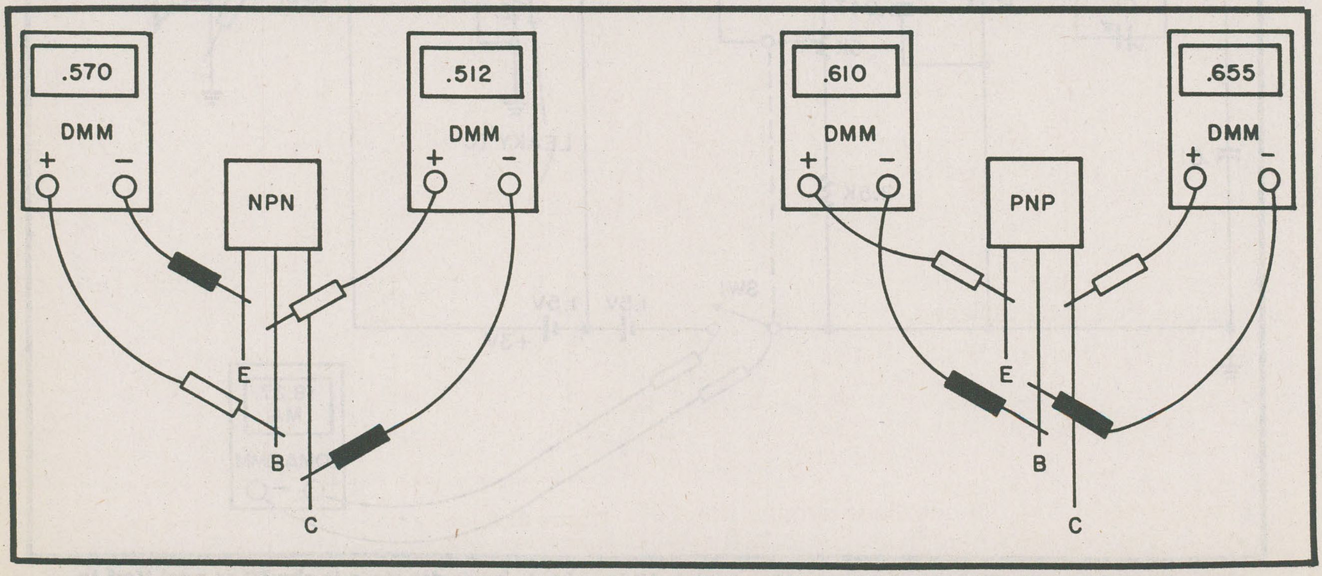


Figure 6: The type of transistor may be identified with transistor-diode junction tests of the DMM. Check the NPN or PNP transistor.

The transistor is normal if the two resistance measurements between the base and the remitter, and the base and the collector terminals are close (Figure 6).

Remember, the transistor junction may be open from the base to either collector or emitter elements. Be very careful in taking transistor tests. You may find the transistor open between two elements or all three. Figure 7 shows a transistor that is normal between the base and the collector, but open between the base and the emitter.

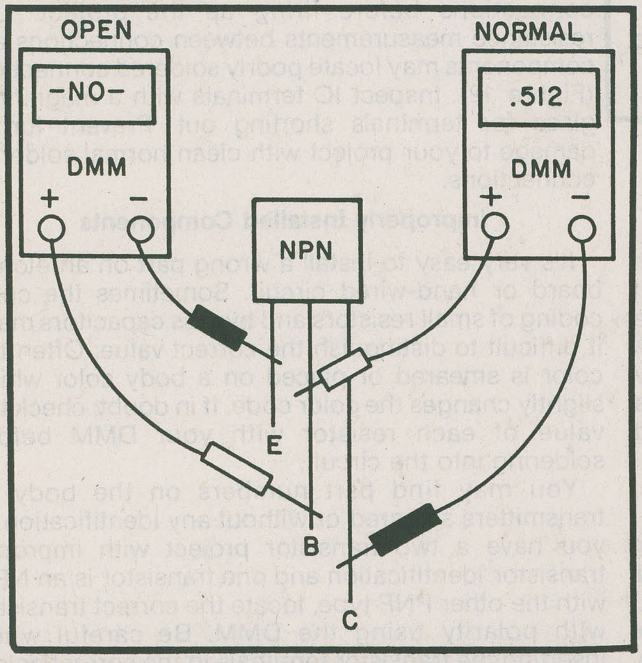


Figure 7: You may find the transistor open or leaky between any two elements. Here the transistor is open between emitter and base terminals.

A very low resistance measurement between any two terminals may indicate the transistor is leaky. Often the leakage exists between collector and emitter terminals (Figure 8). Reverse the ohmmeter terminals when a low measurement is found between two elements. A leaky transitor will now have a low measurement in both directions. Always replace the transistor if leakage is suspected.

Remove the suspected transistor and take another measurement when it is out of the circuit. Usually a transistor with a dead short between emitter and collector will test the same when out of the circuit. An erractic or intermittent transistor will produce erratic measurements with in-circuit tests. Sometimes when the transistor is removed from the circuit, after testing leaky or open in the circuit, it may test normal. Such transistors should be replaced.

Checking Those Diodes

Most diodes can be checked with the diode test of a DMM. Although diodes may be checked in-circuit with the DMM, remove one terminal for accurate leakage tests (Figure 9).

Often the positive or cathode diode terminal may be indicated with a white ring or beveled end. A shorted or leaky diode will show a reading in both directions. A normal diode will indicate in only one direction.

Check the diode by placing the DDM test probes on each terminal. You should get a low resistance measurement with the negative (black) probe on the positive terminal and the positive (red) probe at the negative terminal of the diode (Figure 10). Now, reverse the two probes and make another test. No measurement indicates the diode is normal. Suspect a leaky diode if the resistance is low in both directions.

RF and zener diodes may be checked in the same manner as a fixed diode. Usually, zener diodes are found to be leaky, not open. An RF diode will have a higher resistance than silicon diodes. Leaky, high voltage diodes found in a TV chassis can not be tested succesfuly, unless a dead short exists.

Locating Leaky ICs

Integrated circuits are difficult to test except for voltage and resistance measurements. Open components inside the IC may not indicate with voltage and resistance checks. Sometimes accurate voltage and resistance measurements at each IC terminal will locate the leaky IC. Signal in and signal out tests witha scope are the best methods to locate a defective IC component.

You can check the suspected IC in your dead project with accurate voltage and resistance measurements (Figure 11). The most critical voltage test is at the supply terminal. All IC components have one terminal tied directly to the battery or power supply source. A leaky IC will have lower voltage at the supply terminal. Suspect a leaky IC when voltage is lower at any terminal than shown on the schematic.

After locating a low voltage measurement, take a low-ohm measurement from the IC pin to ground. Remove the suspected terminal from the pc wiring.

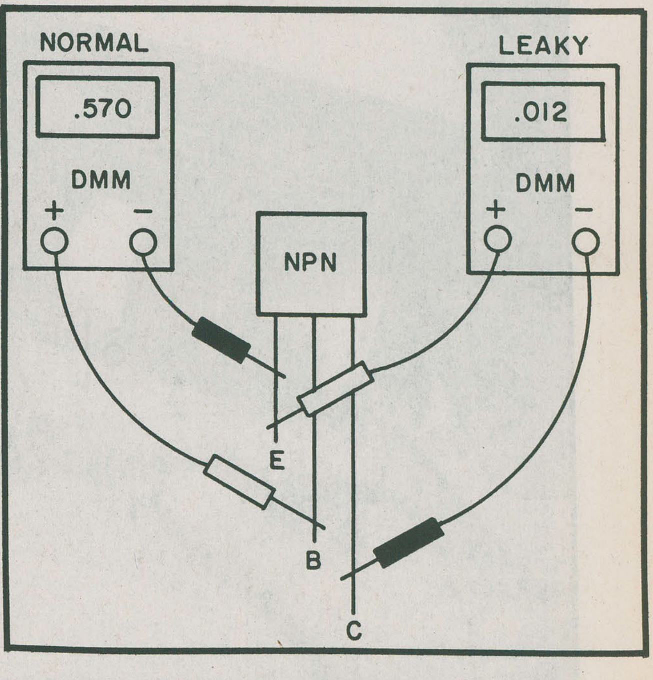


Figure 8: A leaky transistor will have a low-ohm measurement in both directions. Here an NPN transistor is leaky between emitter and collector terminal.

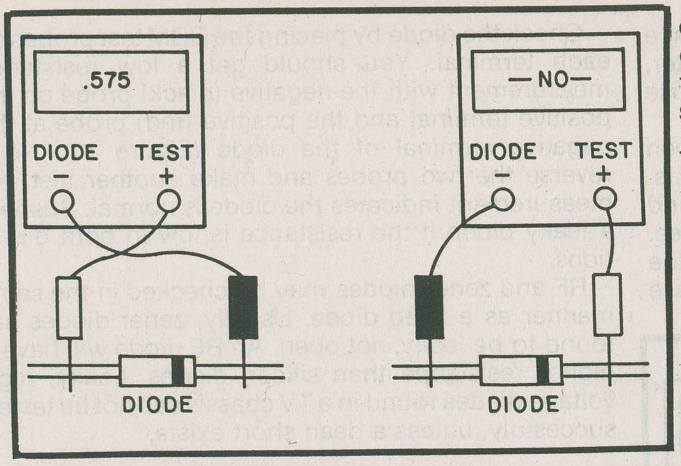


Figure 9: A normal diode will have low resistance in one direction and no reading with reversed test probes. A leaky diode will have low resistance in both measurements.

Always check the circuit to make sure a low ohm resistor, coil, transformer winding or diode is not shunted from this terminal to ground. Now, measure the resistance between the terminal and ground. A low resistance (under 1000 ohms) indicates a leaky IC. Supply insert another IC if the component is plugged into the IC socket. Often ICs are damaged when removed from the circuit with a soldering iron.

Poorly Soldered Connections

Improper soldered contacts may cause dead or intermittent project operation. The cold soldered connection may have a high resistance joint. Sometimes a poorly soldered connection between component terminal and etched wiring will result in erratic operation. Always apply the solder to the wire connections, not to the end of the iron. Solder should flow into the joint for a good clean connection. Make sure each wire is connected to the right component or joint.

Of course, too much solder around transistor or IC terminals may slop over, tying terminals and components together. Remember to use a heat sink on transistor terminals when soldering into the circuit. Use IC sockets instead of soldering ICs directly into the etched wiring. Double check all connections before firing up the project. Low resistance measurements between connections and components may locate poorly soldered connections (Figure 12). Inspect IC terminals with a magnifying glass for terminals shorting out. Prevent further damage to your project with clean normal soldering connections.

Improperly Installed Components

It's very easy to install a wrong part on an etched board or hand-wired circuit. Sometimes the color coding of small resistors and bypass capacitors make it difficult to distinguish the correct value. Often the color is smeared or placed on a body color which slightly changes the color code. If in doubt, check the value of each resistor with your DMM before soldering into the circuit.

You may find part numbers on the body of transmitters smeared or without any identification. If you have a two transistor project with improper transistor identification and one transistor is an NPN with the other PNP type, locate the correct transistor with polarity using the DMM. Be careful when inserting the transistor terminals in the correct holes.

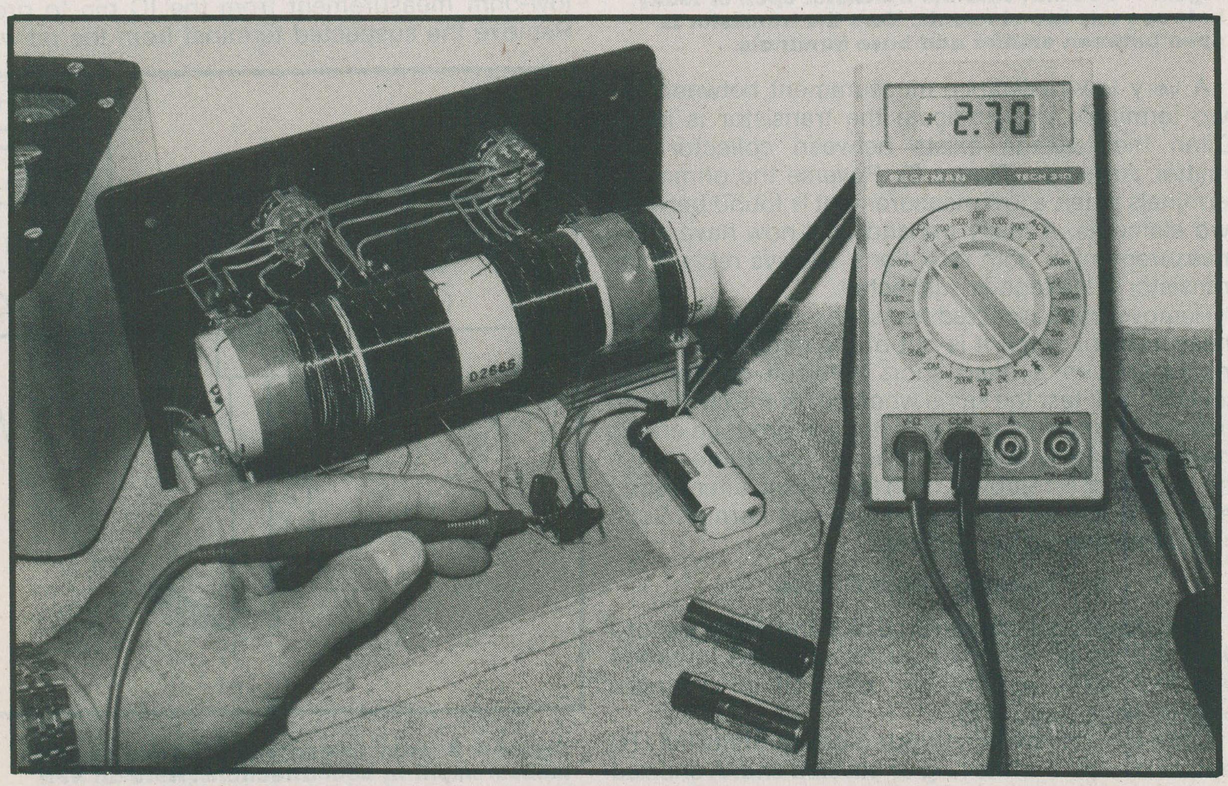


Figure 10: Diodes may be checked in the circuit for normal tests. Remove one end of the diode when leakage is noted for accurate leakage measurement.

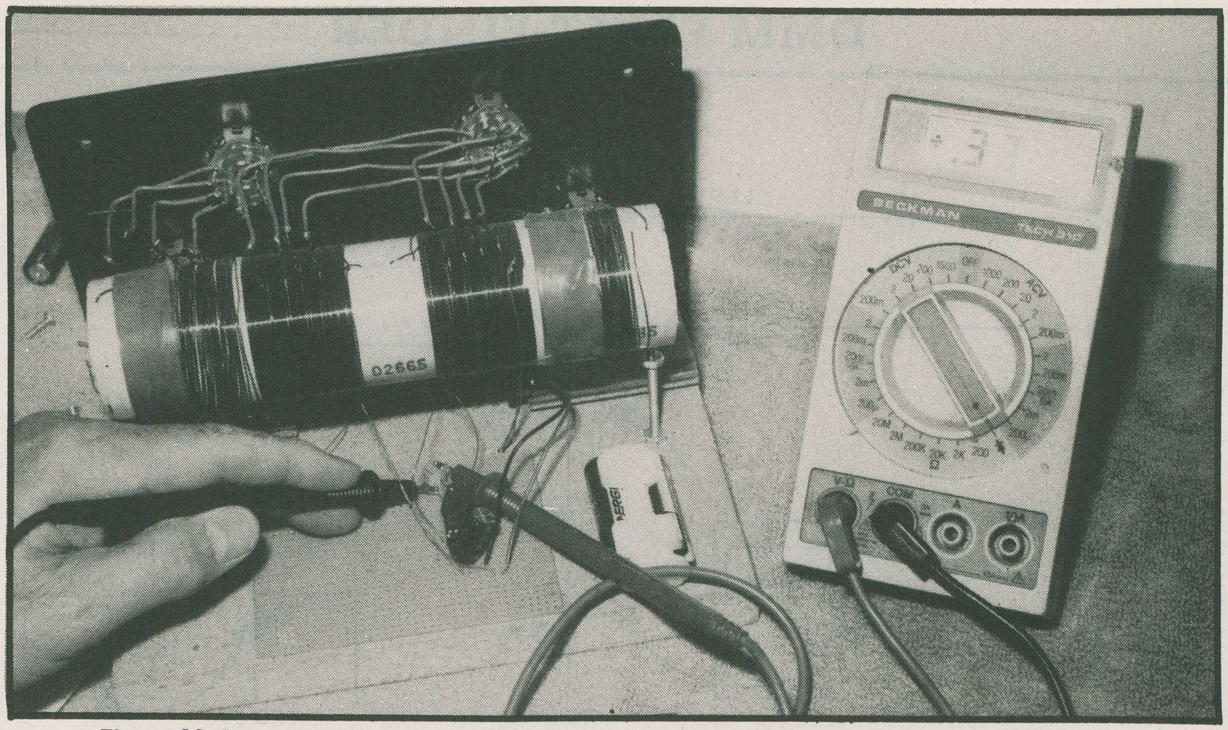


Figure 11: Low voltage measurements on the suspected IC may indicate a leaky IC. Check the battery or power supply with the IC removed from the circuit.

Have the bottom view of the transistor handy at all times. Besides having a project that will not work, connecting the wrong terminals may destroy the new component.

Defective New Components

Do not overlook a possible defective component. Try to test each part before installing it in your project. You will know if the part is defective or breaks down after it's installed in the circuit. Make sure that the part is good before installation.

Transistor, diodes and resistors are easily checked with the DMM. IC components may be checked in the circuit with accurate voltage and resistance measurements (Figure 13). Small capacitors may be checked with a capacitor tester or with a DMM which

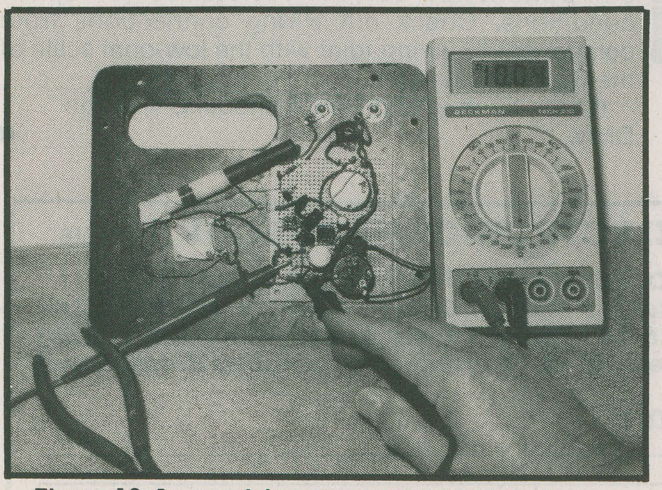


Figure 12: Low resistance measurements between wiring and parts may locate a poorly soldered connection. Check each resistor for correct resistance. Remove one end of the resistor.

also incorporates a capacitor checker. Variable resistors may be checked from center terminal to each outside terminal with high resistance measurements. Low-ohm continuity tests on coils, transformers and relays will indicate if the part is open. Check for broken wire leads at the component lugs or terminals.

Before installing a variable capacitor in a project, take a high resistance measurement (20K) between the ground and the rotor or stator terminals. Sometimes in shipment, the metal plates are damaged or pressed together. The normal variable capacitor has infinity between terminals. You can not tell if the capacitor is shorted when installed with the coil shunted across the capacitor terminals in the circuit, because the coil will show zero resistance.

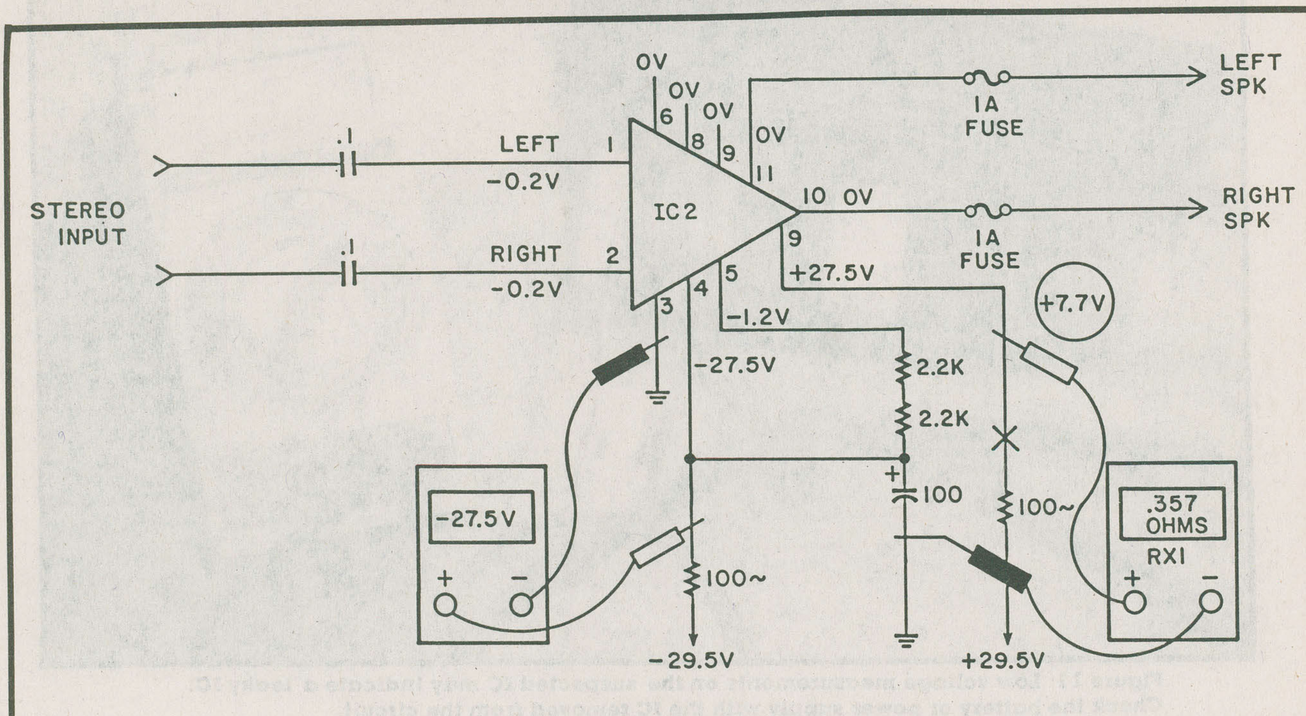
Improper Schematic

Missing lines or improper connections in a schematic diagram may prevent the project from operating. Mis-labeled parts can cause problems in getting the project to work. A ground or tie wire left out of the schematic will produce many problems. Wrong polarity symbols for battery terminals (interchanged) can hook up the battery backwards in the circuit. Although magazines and books check and proof read all material, little errors somehow can creep in. Check with the magazine, book or manufacturer for possible wiring defects after going over the wiring many times. Most magazines re-run corrections of mistakes made in the project content.

Conclusion

You have heard it said many times, double check all wiring connections. Remember, even the most experienced builder can make mistakes in wiring an electronic project. Take voltage and resistance

DMM FAULT-FINDER



CIRCLED VOLTAGE WITH LEAKY IC2 (+7.7V). OHMMETER TEST WITH LEAKY IC, PIN 9 TERMINAL REMOVED FROM CIRCUIT (.357 OHMS). NORMAL NEGATIVE VOLTAGE MEASURED AT PIN 4 (-27.5V).

Figure 13: Most components can be checked before they are installed in the circuit with the DMM. Correct voltage and resistance tests at each terminal of an IC may locate the leakage.

Figure 14: Accurate voltage and resistance measurements upon the various components may locate the defective part or improper wiring. Check and compare these measurements with those found upon the schematic.

measurements to locate the possible defective component or wiring error (Figure 14). Next, take a milliampere measurement for excessive current.

Check the suspected transistor or diode with the transistor-diode test of the DMM. Make sure that all diode and/or transistors are installed properly. Take low voltage and resistance measurements at each IC terminal. Take resistance and continuity tests on each component for correct resistance (or open) conditions. Check out wiring connections from component to wiring joint with the low-ohm scale of the digital multimeter.

Happy hunting and troubleshooting with the DMM. ■

TRASH CAN SPEAKER SYSTEM

By Barry Flick

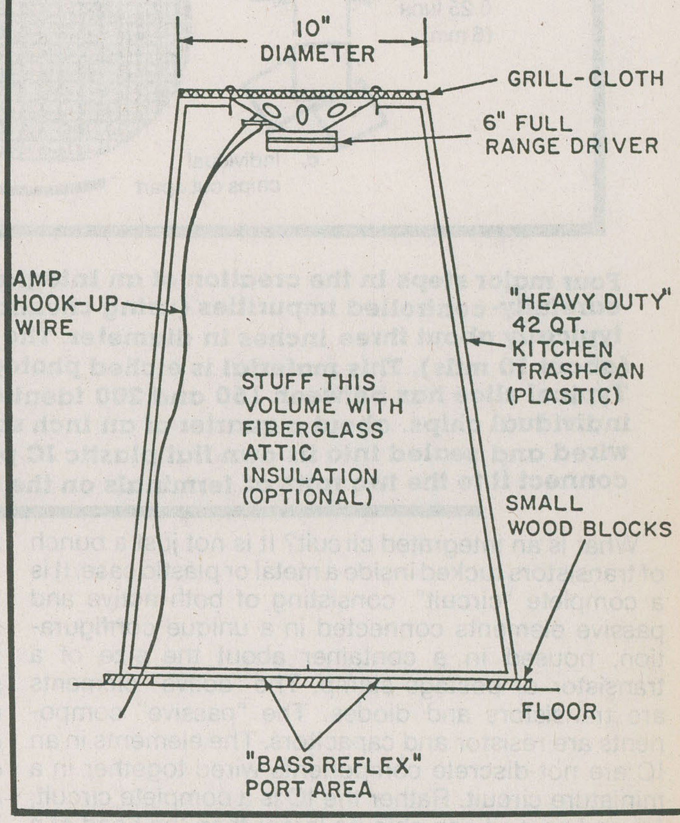
Every loudspeaker requires a baffle. In the most general terms, the baffle can be described as the structure that surrounds the "raw driver" and makes it sound right in the listening room. Here is an idea for a speaker system that was suggested to me back in the late 1960's at a time when "omni-directional" speakers were more popular than they are now.

Omni-directional speakers differ from more conventional direct-radiating speakers in that they do not have a flat baffle board on which the drivers are mounted facing the listener thus radiating the sound directly at the listener. Instead, "omnis" radiate the sound into the room as a whole: toward the ceiling, toward the floor, or all the walls at once. Many people think this gives the sound a "laid back" ambient quality with a smooth pleasing reponse. Others think it has a tendency to blur the sound coming from the two stereo channels, thus causing an indistinct and confusing stereo image. The history of high fidelity has always been full of such controversies.

In any event, here are some plans for constructing an inexpensive, quick, and easy-to-build "omni" system. This speaker system will work best when coupled to the relatively "low-cost" department store variety stereo system which normally comes with a pair of relatively poor quality, four or five-inch, limited range speakers. If you own a state-of-the-art hi-fi system with high quality speakers to begin with, you probably won't want to go this route.

First, you will need a pair (for stereo) of decent quality six-inch wide-range raw speakers. Radio Shack catalog #40-1242, priced at $5.95 each is a good choice. Next, visit your local department or hardware store, tape measure in hand, and look for a pair of heavy duty kitchen-type plastic trash cans. These cans are round and usually have a capacity of 30 to 40 quarts. The only "critical" dimension of our trash cans is the diameter of the bottom. It must be at least large enough to accomodate the cut out hole of the six-inch speaker, and still retain considerable strength. A diameter of about ten or more inches should be satisfactory; measure to be sure. The trash cans should be as thick and dense a material as you can find and I prefer "rubbery-flexible" kind of plastic to the "hard-brittle" kind because of possible vibration problems. The overall dimensions of the trash cans are not critical, however they should have a partial conical shape as practically all trash cans of this type do, and not a perfect cylindrical shape. This is to prevent a resonant peak in the bass response and I think it makes the finished system look better.

Cut a round hole in the top of the speaker enclosure (the bottom of the trash can) marking it with a compass or other suitable round object of the proper diameter to accomodate the six-inch speaker. An old soldering iron works very well to melt the hole, however, be very careful to end up with a smooth edge. With the holes finished use small carriage bolts or similar fasteners to mount the speakers on the inside of the enclosure pointing straight up. It's a good idea to solder the speaker hook-up wire (amp connection) to the speakers before installing in the enclosures.



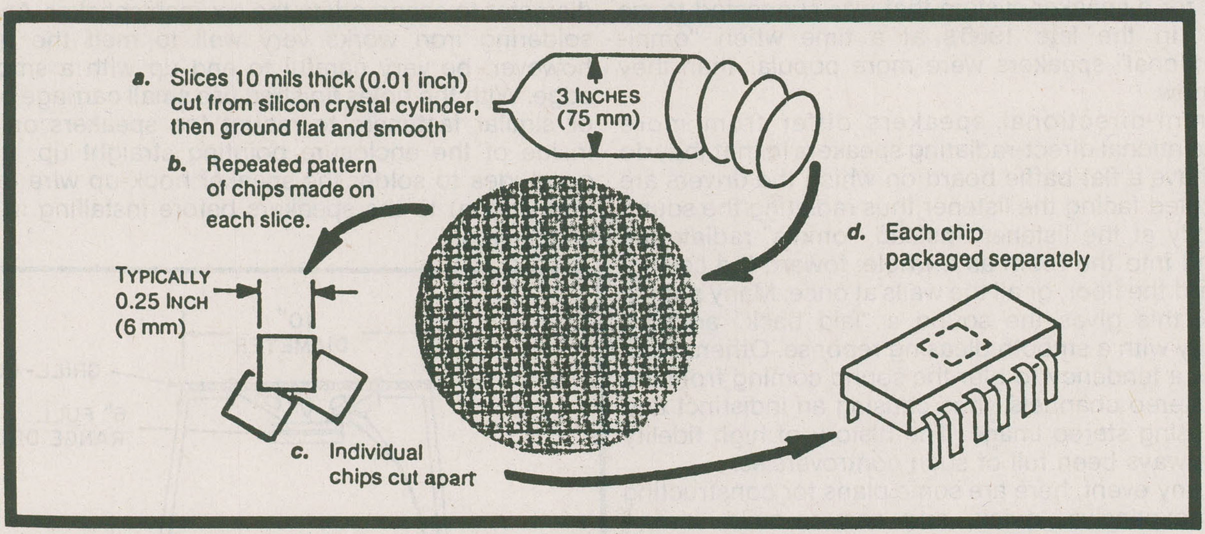
Cut a couple of pieces of grill cloth material and epoxy cement them over the top of the enclosures to protect the drivers. You can buy grill cloth material from Radio Shack or use any cloth that has a very loose weave. If you can see through it when it is held up to the light, it is probably suitable.

(Continued on page 96)

THE FUNDAMENTALS & FLEXIBILITY OF INTEGRATED CIRCUITS

by Wm. A. Templin

Integrated Circuits, The Brains of Today's Electronics



Four major steps in the creation of an Integrated Circuit chip. In (a) the silicon, made of carefully- controlled impurities (using chemical dopants) is grown as a cylinder which is typically about three inches in diameter. The cylinder is then sliced into thin slices (about 10 mils). This material is etched photographically in (b), into microscopic pattern(s) Typical slice has between 150 and 200 identical chips. These chips are then separated into individual chips. about a quarter of an inch square (c). After cutting apart each chip is wired and sealed into its own flat plastic IC package (d) along with the tiny wires which connect it to the two rows of terminals on the sides. (Courtesy of Radio Shack)

What is an integrated circuit? It is not just a bunch of transistors tucked inside a metal or plastic case. It is a complete "circuit", consisting of both active and passive elements connected in a unique configuration, housed in a container about the size of a transistor or postage stamp. The "active" elements are transistors and diodes. The "passive" components are resistor and capacitors. The elements in an IC are not discrete components wired together in a miniature circuit. Rather the IC is a complete circuit, formed on a silicon chip no larger than the head of a pin. The IC circuit "road map" can be seen only under very high magnification.

ICs are fabricated on a silicon disk approximately one inch in diameter and about the thickness of a piece of paper. The disk is altered in a series of individual steps. The top of the disk is first oxidized, then covered with photosensitive lacquer, called a "resist." Circuit patterns are etched into the oxide by a microphotolithographic process. After heating, minute quantities of "impurities" or dopants, such as boron or arsenic, are diffused into the silicon to form the "P" (electron deficient) and "N" (electron surplus) islands on the disk. The process is repeated many times until all the circuit elements, (transistors, diodes resistors and capacitors), are created on the disk. The various elements are connected by depositing vaporized aluminum in the desired pattern to form the proper circuitry. The completed disk may have as many as 200 ICs on it. These are then diced, separated, tested, and mounted on ceramic or metal bases. Then aluminum wires, about one-third the thickness of a human hair, are bonded between the IC contacts and the pinout connections. The package is then sealed.

ICs come in several different case styles. Some are

packaged in small round metal cases with the leads arranged in a circular pattern on the bottom of the case. This is the familiar TO-5 case. Other ICs come in another very common package known as a DIP (Dual In-line Package). The IC leads are arranged in two (dual) parallel sections along the sides (in-line) of the package. ICs are available in DIP packages with 6, 8, 14, 16, 24, 32 and 40 pinouts or leads.

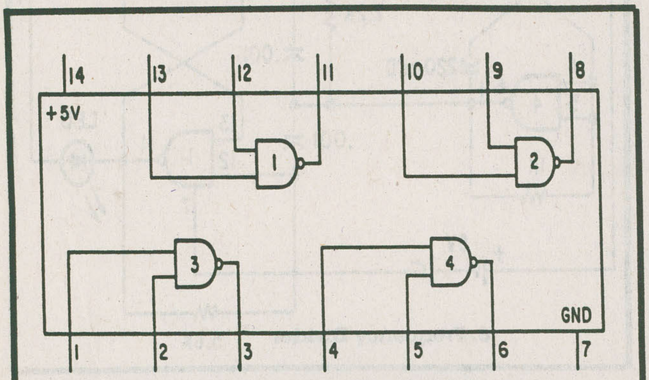


Figure 1. Quad 2 input NAND Gate

The concept of integrated circuits was an outgrowth of printed-circuit techniques. It was only natural, at the start of IC technology, to attempt to develope ICs in the image of conventional transistor circuits, and so early IC circuit design closely resembled transistor circuits using discrete components. However, as the body of knowledge and experience grew, IC circuits took on a character all their own. Anyone knowledgeable in conventional transistor circuitry, upon seeing an IC circuit arrangement for the first time, might be rather startled and find it hard to relate the circuit design to the specific function.

The reason IC circuitry is uniquely different from conventional circuitry is closely related to the methods and economics of the fabrication process and to the size of the chip. In conventional circuit design employing discrete components, the "active" elements (transistors and diodes) are more costly than resistors and capacitors. In IC technology, transistors and diodes are less costly than resistor and capacitors. The reason is that transistors and diodes take up very little space on the chip, whereas, resistors and capacitors require a relatively large amount of room. For this reason, IC designers make

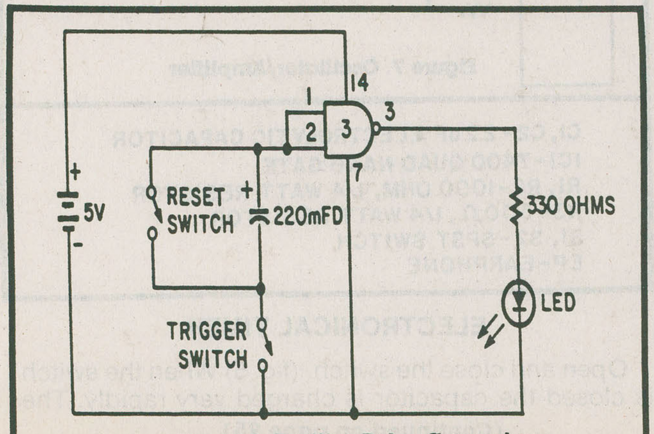


Figure 2. Positive Pulse Generator

extensive use of "active" elements and use the "passive elements" sparingly.

An important consideration in the creation of IC chips is flexibility. Chips are designed to be used in more than one circuit configuration. This interchangeability is made possible by rearranging various discrete external components. For example, the same chip with different external circuit arrangements may be used as a positive pulse generator, as a negative pulse generator, as a continuity tester, as an electronic timer, as a frequency divider, or as an oscillator/amplifier circuit. Chip Flexibility is made possible by the fact that circuit leads on the body of the IC make it possible to break into the circuit arrangement at critical points within the IC configuration.

To prove the statement that ICs are flexible, let's use one chip, and by rearranging the various external components, build the circuits listed above. The integrated circuit chip used in these demonstration projects is a 14-pin DIP. It is an SN7400 quad 2 input NAND gate (fig.1). The Sn7400 can be purchased at Radio Shack for a very modest price. This chip is the basic building block for the entire TTL (transistor-transistor logic) family. It is very easy to use and has

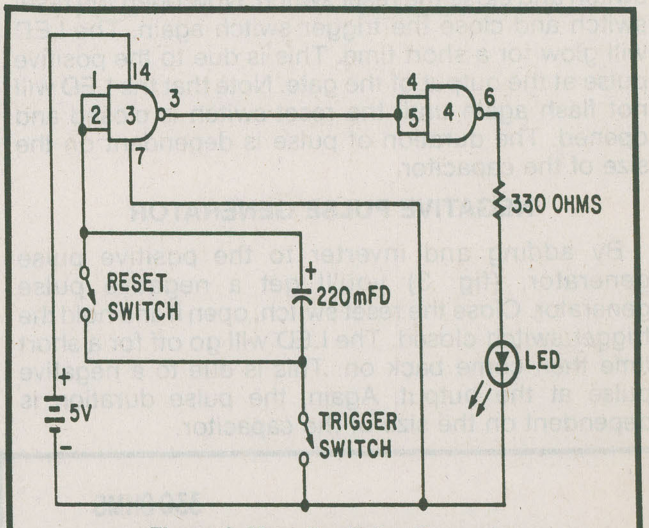


Figure 3. Negative Pulse Generator

hundreds of applications. The NAND gate is so flexible that it can be used to create all the other members of the logic family (AND, OR, NOR, EXCLUSIVE OR and EXCLUSIVE NOR).

TTL chips are classed as digital and used mostly in computors, as opposed to linear (analog) chips which are used mostly in amplification. However, a digital IC can sometimes be used in a linear application and a linear IC can sometimes be used in a digital application. This will be seen in some of the projects where a NAND gate is used as an amplifier.

Before beginning these demonstration projects, keep in mind that the operating voltage for the SN7400 is 5 volts. If you have a 5 volt regulated power supply, fine, but three 1.5 volt AA batteries connected in series will work just as well. If you use batteries disconnect them when you are finished so their power will not be drained. I also recommend using a bread-board from Radio Shack. That way when you

are done with one project you can just unplug the discrete external circuitry from the board and start on the next project.

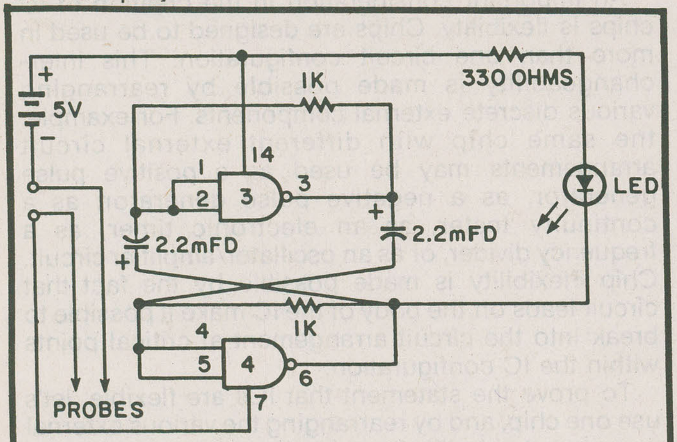


Figure 4. Continuity Tester

POSITIVE PULSE GENERATOR

This positive pulse generator (fig. 2) will generate a positive pulse when the trigger switch is held closed. To get another pulse, you have to release the trigger switch and close the reset switch. Now open the reset switch and close the trigger switch again. The LED will glow for a short time. This is due to the positive pulse at the output of the gate. Note that the LED will not flash again until the reset switch is closed and opened. The duration of pulse is dependent on the size of the capacitor.

NEGATIVE PULSE GENERATOR

By adding and inverter to the positive pulse generator, (fig. 3) you'll get a negative pulse generator. Close the reset switch, open it and hold the trigger switch closed. The LED will go off for a short time then come back on. This is due to a negative pulse at the output. Again, the pulse duration is dependent on the size of the capacitor.

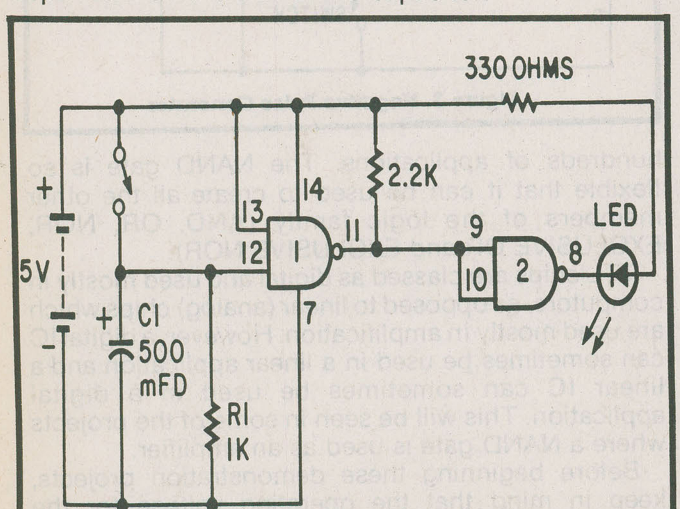
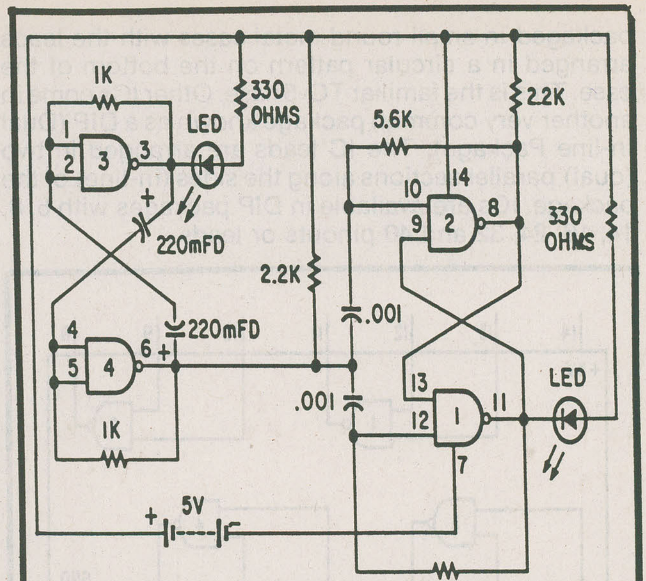


Figure 5. Electronic Timer Figure

CONTINUITY TESTER

The continuity tester (fig. 4) is a device to check for open circuits in electrical equipment. The LED will



6. Frequency Divider

flash only if the circuit being tested is unbroken. The LED will emit no light if the circuit being tested is open or broken.

CAUTION: BE SURE THAT THE DEVICE BEING TESTED IS NOT CONNECTED TO ANY ELECTRICAL SOURCE.

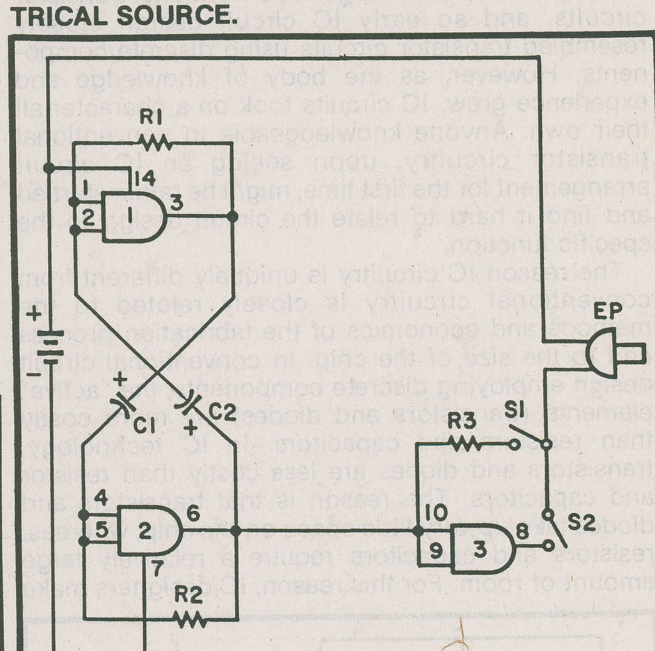


Figure 7. Oscillator/Amplifier

C1, C2 - 2.2uF ELECTROLYTIC CAPACITOR
IC1 - 7400 QUAD NAND GATE
R1, R2 - 1000 OHM, 1/4 WATT RESISTOR
R3 - 300Ω, 1/4 WATT RESISTOR
S1, S2 - SPST SWITCH
EP - EARPHONE

ELECTRONICAL TIMER

Open and close the switch. (fig. 5) When the switch is closed the capacitor is charged very rapidly. The

(Continued on page 95)

WORKBENCH PROJECTS

The projects we've prepared for you in this section are more complicated than those in our **Circuit Fragments** section, but they are less complicated than the ones in our **IC Testbench** section.

As with any electronics assembly work, be sure you understand how the various parts of the circuit work together and the objective of each component before you start gathering the components together and assembling them. As with any project that uses ICs (integrated circuits) or transistors, be careful to observe precautions regarding overheating their leads. If possible, use sockets instead of soldering directly to their wire leads. If you can't do that, be sure to protect the IC and transistor leads by using long-nose pliers as a heat sink when soldering those leads.

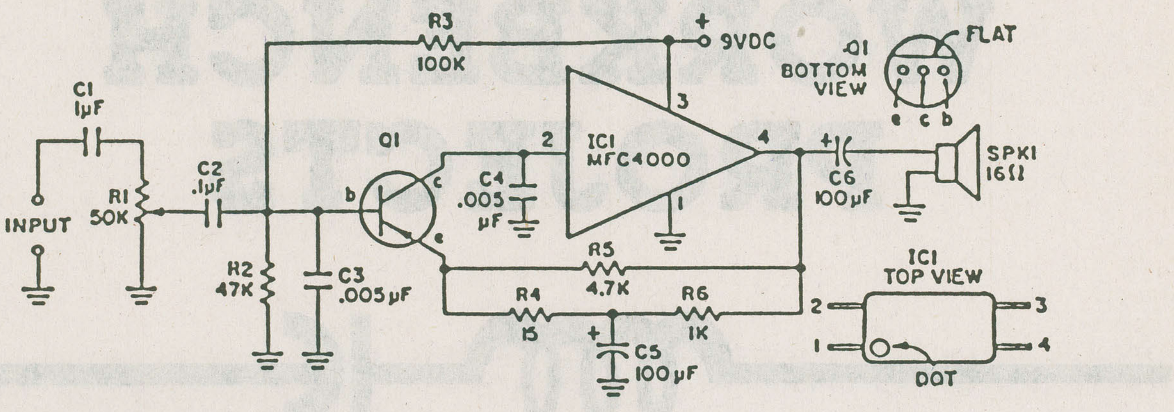
MINIATURE IC SIGNAL TRACER

Featuring extremely high gain suitable for tracing signals directly from microphones and magnetic pickups, our signal tracer can be made small enough to sit directly on the back of the speaker magnet. Though intended for checking transistor circuits, it can be used with tubed equipment if capacitor C1 has a 600 VDC minimum rating, and if volume control R1 is always started from its off position. Regardless of the size speaker used, the speaker impedance must be 16 ohms minimum though higher impedances work better. Power output is approximately 250 mW; more than sufficient output level from a solid-state signal tracer small enough to hide on the back of a speaker magnet.

PARTS LIST FOR MINIATURE IC SIGNAL TRACER

C1—0.1-uF, 600 VDC capacitor (see text)
C2—0.1-uF, 10 VDC capacitor
C3, C4—.005—uF, 10 VDC capacitor
C5—100-uF 3 VDC
C6—100-uF, 10 VDC capacitor (250 uF for better low-frequency response)
IC1—Motorola MFC-4000
R1—Potentiometer, 50,000-ohms audio taper
R2—47,000-ohms, resistor
R3—100,000-ohms, resistor
R4—15-ohms resistor
R5—4,700-ohms resistor
R6—1,000-ohms resistor
Q1—PNP transistor, Radio Shack 276-2021
SPK1—Miniature speaker (see text)

MINIATURE IC SIGNAL TRACER



STEREO SPEAKER PROTECTOR

The advent of the superamplifier, capable of supplying 100 to 200 watts per channel on a continuous basis, has been both a blessing and a curse to the audiophile. The blessing is that a recording's dynamic range can now be more faithfully reproduced, even with inefficient loudspeakers. Unfortunately, these amps are so powerful that loudspeakers can often be overdriven and eventually destroyed, if sufficient care is not exercised. If your amp lacks provisions for speaker protection, you may want to build the speaker protector diagrammed here.

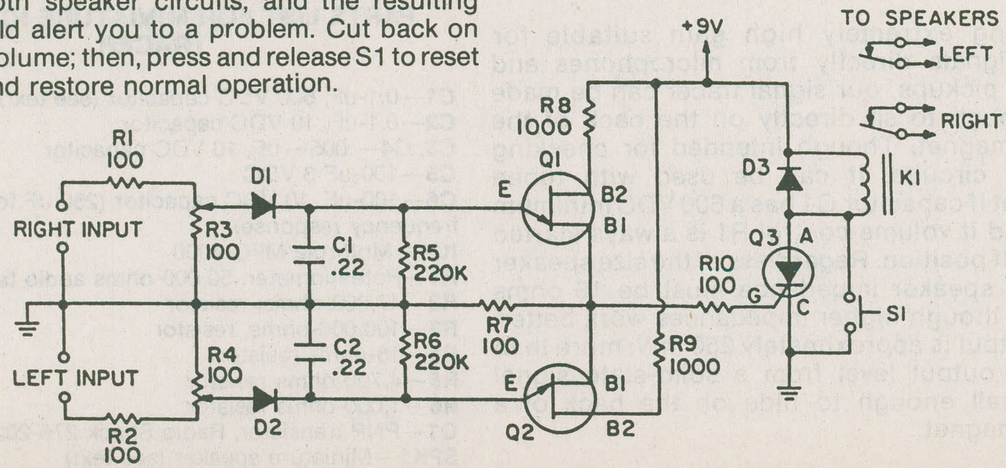
The contacts of relay K1 are hooked in series with your right-and left-hand speakers in such a way that, when K1 is unenergized, its contacts close and complete the circuit to each loudspeaker.

Inputs to the protection circuit come from your amp's outputs (the same outputs that drive the speakers). If the signal feeding the 'right' input is sufficiently large to charge C1 to a potential greater than the breakdown voltage of Q1's emitter, a voltage pulse will appear across R7. Similarly, excessive inputs to the 'left' channel will also produce a pulse across R7, this time due to the discharge of C2 by Q2. The pulse across R7 triggers SCR Q3, which latches in a conducting state and energizes K1. This interrupts both speaker circuits, and the resulting silence should alert you to a problem. Cut back on your amp's volume; then, press and release S1 to reset the circuit and restore normal operation.

The circuit can be adjusted to trip at lower levels from 15 to 150 watts rms. To calibrate, feed a deliberately excessive signal to the 'right' input, and raise R3's wiper up from ground until K1 pulls in. Disconnect the signal from the 'right' input, and apply it to the 'left' input. Press S1 to reset the circuit, and raise R4's wiper up from ground until K1 pulls in again. The circuit is now calibrated. Your calibration signal should preferably be a continuous tone, but a musical passage of fairly constant loudness will probably suffice. K1's contacts should be rated to carry a 3- to 5-amp load.

PARTS LIST FOR STEREO SPEAKER PROTECTOR

C1, C2—.22 uF capacitor
D1, D2, D3—1N914 diode
K1—6-volt relay, DPDT contacts (see text)
Q1, Q2—2N2646 unijunction transistor (Radio Shack RS2029)
Q3—2N5060 sensitive-gate SCR
R1, R2—100-ohm, ½-watt resistor 10%
R3, R4—100-ohm linear-taper potentiometer
R5, R6—220K-ohm, ½-watt resistor
R7, R10—100-ohm, ½-watt resistor
R8, R9—1,000-ohm, ½-watt resistor
S1—N.O. pushbutton switch

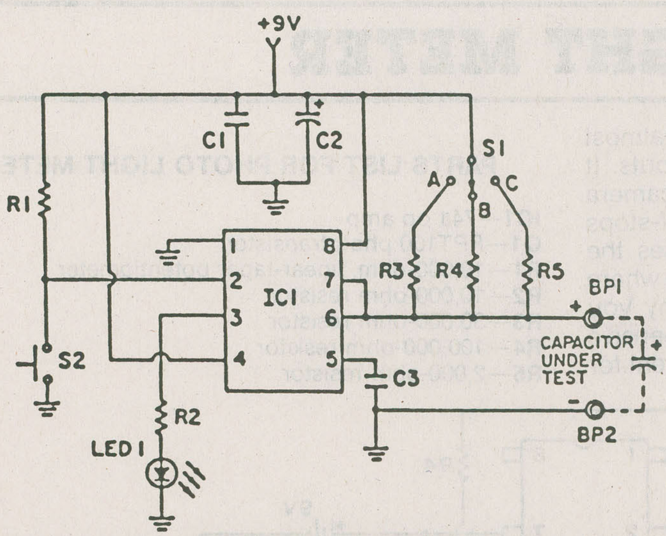


ELECTROLYTIC CAPACITOR TESTER

Here's a quick and simple way to check out all those old electrolytic capacitors in your junkbox. Besides this simple 555 timer circuit, you will need a timepiece with a readout in seconds; the readout may be digital or just an ordinary sweep-second hand. Connect the capacitor to be tested to the binding posts, being careful to observe proper polarities. Now, press S2 and note how long LED 1 stays lit. Multiply the time by the appropriate scale factor to obtain the capacitance. For example, suppose you happen to be checking a very large filter capacitor, which would require that scale C, 100 uF/sec, be used. If the LED remains lit for 67 seconds, the capacitance is 67×100 or 6700 microfarads.

PARTS LIST FOR ELECTROLYTIC CAPACITOR TESTER

BP1, BP2—binding post
C1, C3—0.1-uF capacitor, 35 VDC
C2—100-uF electrolytic capacitor, 16 VDC
IC1—555 timer
LED1—light-emitting diode
R1—100K-ohm resistor
R2—560-ohm resistor
R3—910K-ohm resistor
R4—91K-ohm resistor
R5—9100-ohm resistor
S1—single-pole, 3-position rotary switch
S2—normally open SPST pushbutton switch



TIME SCALE TABLE

Range	Scale
A	1uF/second
B	10uF/second
C	100uF/second

PHOTOELECTRONIC ANNUNCIATOR

Momentarily interrupt the beam of light shining on Q1, and you get a one-second "beep" from this circuit. Most likely you've encountered circuits of a similar nature in retail stores, where the buzzing sound signals your entrance and alerts salesmen to their prey. Obviously, a great many other applications are possible as well.

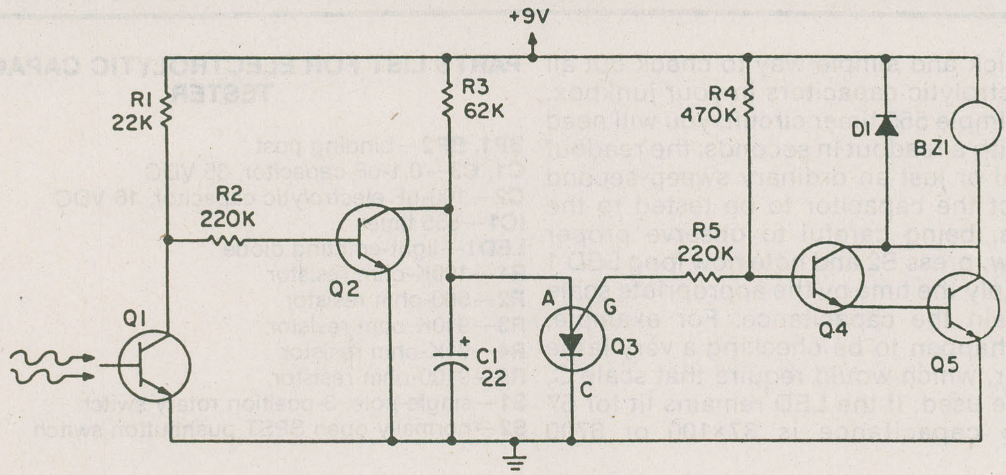
With light shining on Q1's sensitive face, the phototransistor conducts heavily and shunts current away from the base of Q2. But when the beam of light is interrupted, Q1 ceases to conduct—thus allowing current to flow through R1 and R2 into Q2's base. The collector of Q2 then conducts current and rapidly discharges capacitor C1. This allows Q3's gate lead (G) to swing high, thereby turning on Q4, Q5 and the buzzer.

Assuming that the interruption of the beam was only temporary, Q2's collector will now have ceased to conduct current. This allows C1 to charge until it reaches a level sufficient to trigger Q3, a programmable unijunction transistor (PUT). When that happens (in about 1 second), Q3's gate potential drops, which turns off Q4, Q5 and buzzer. Another interruption will repeat the whole process and yield one more "beep."

PARTS LIST FOR PHOTOELECTRONIC ANNUNCIATOR

BZ1—piezoelectric buzzer, 6-9 VDC
C1—22 uF, 16V electrolytic capacitor
D1—1N914 silicon diode
Q1—FPT-100 NPN phototransistor
Q2, Q4, Q5—2N3904 NPN transistor
Q3—2N6027 programmable unijunction transistor
R1—22,000-ohm, ½-watt resistor, 10%
R2 R5—220K-ohm, ½-watt resistor, 10%
R3—62,000-ohm, ½-watt resistor, 10%
R4—470K-ohm, ½-watt resistor, 10%

PHOTOELECTRONIC ANNUNCIATOR

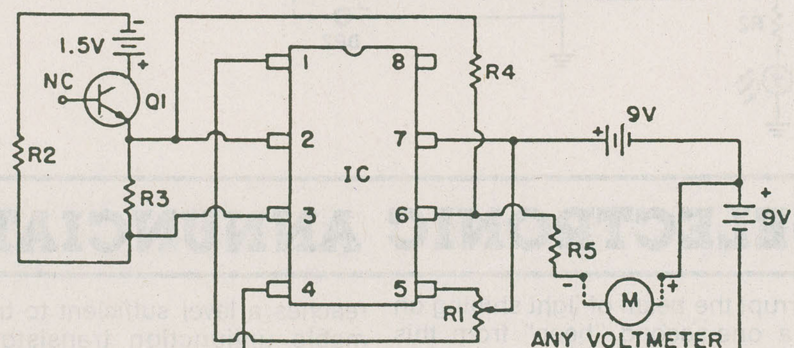


VOM PHOTO LIGHT METER

The beauty of this light meter is that it is almost perfectly linear over a wide range of light inputs. It provides you with the basic operation of a camera light meter and can be made to read directly in f-stops and shutter speed. Phototransistor Q1 senses the light level and passes that on to the 741 op amp where the small voltage is amplified. Meter M is any you currently have around the house, or any inexpensive meter you can buy. R1 provides a zero adjustment for the meter.

PARTS LIST FOR PHOTO LIGHT METER

IC1—741 op amp
Q1—FPT100 phototransistor
R1—10,000-ohm, linear-taper potentiometer
R2—10,000-ohm resistor
R3—30,000-ohm resistor
R4—100,000-ohm resistor
R5—2,000-ohm resistor



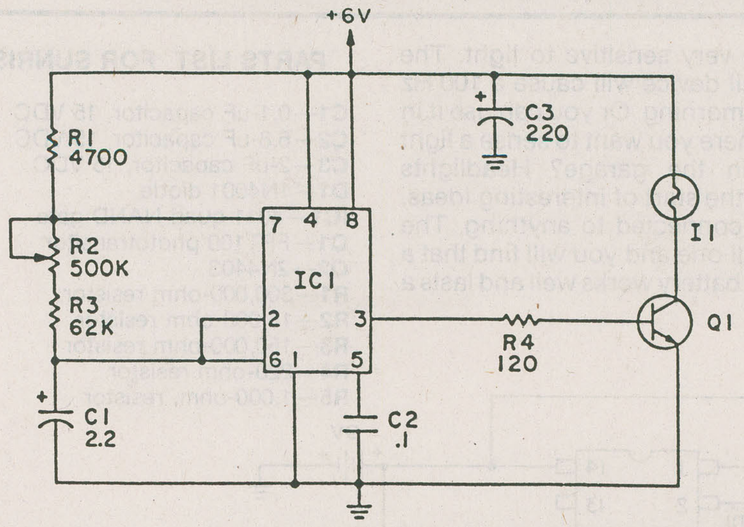
MINI-STROBE LITE

Connect a small 6-volt lamp to a 555 timer, and what do you get? A mini-strobe, that's what! Although the light from lamp I1 is nowhere near as intense as that from the xenon flashtubes used in commercial strobes, you can still obtain a stroboscopic effect in a darkened room. Because incandescent lamps cannot be swtiched on and off as quickly as flashtubes, IC1's maximum frequency has been limited to 5Hz. Still, you can stop human motion for a novel effect. Use a 6-volt lantern battery or four D cells in series to power the circuit.

PARTS LIST FOR MINI STROBE

C1—2.2 uF, 10V electrolytic capacitor
C2—.1 uF ceramic disc capacitor
C3—220 uF, 10V electrolytic capacitor
IC1—555 timer
I1—type PR-12-6-volt, 500-mA lamp (Radio Shack 272-1123)
Q1—2N2222 NPN transistor
R1—4,700-ohm, 10%, ½-watt resistor
R2—500,000 linear-taper potentiometer
R3—62,000-ohm, 10%, ½-watt resistor
R4—120-ohm, 10%, ½-watt resistor

MINI-STROBE LITE

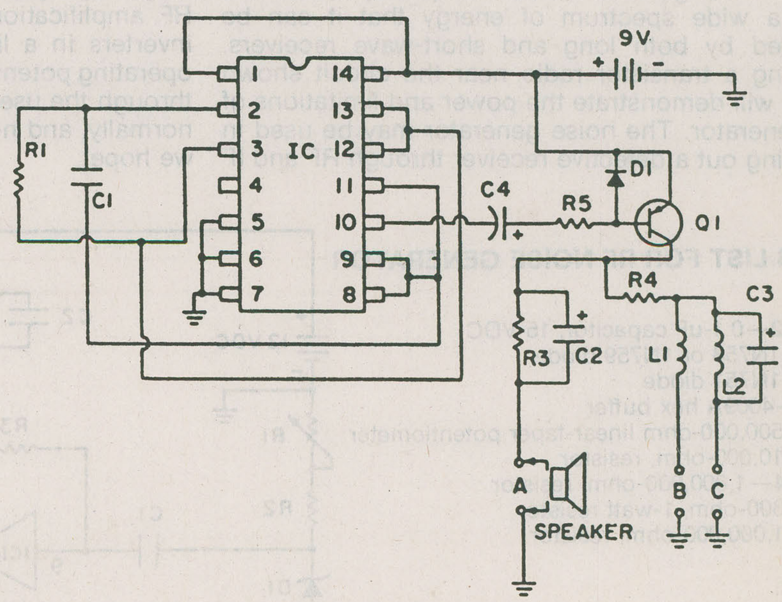


ORGAN-PLUS TONE GENERATOR

Musical organ-like sounds can be generated with this CMOS circuit. The IC generates a nearly square-wave output from pin 11 and the spacings on that output stream of pulses can be varied by changing R1 and R2. If you change them smoothly, you can get a slide-trombone effect. Outputs A, B, and C are different from the pin 4 output in that the square wave now becomes a sawtooth, a spike and a complex combination of both. Rich overtones result that you can hear with the loudspeaker.

PARTS LIST FOR ORGAN-PLUS TONE GENERATOR

- C1—0.2-uF capacitor, 15 VDC
- C2—4.7-uF capacitor, 15 VDC
- C3—6.8-uF capacitor, 15 VDC
- C4—2-uF capacitor, 15 VDC
- D1—1N4001 diode
- IC1—4011 quad NAND gate
- L1—2.5-millihenry RF choke
- L2—2.5-millihenry RF choke
- Q1—2N4403
- R1—20,000-ohm resistor
- R2—100,000-ohm resistor
- R3—220-ohm resistor
- R4—220-ohm resistor
- R5—1,000-ohm resistor
- SPKR.—8-ohms

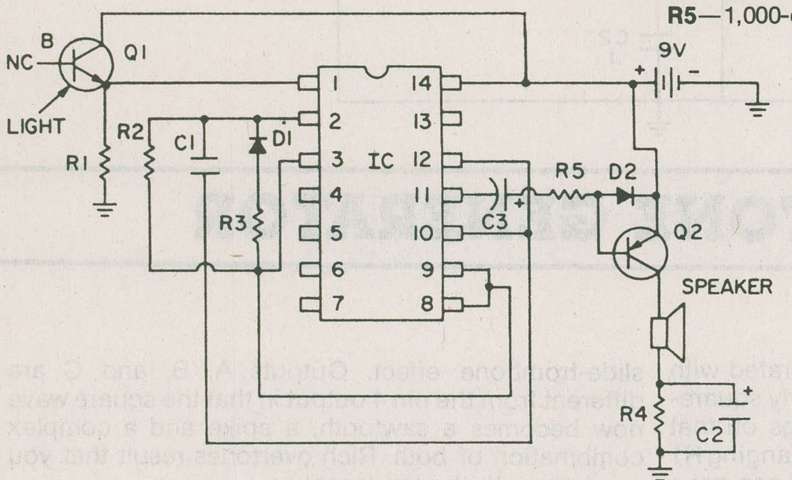


SUNRISE ALARM CLOCK

Phototransistor Q1 is very sensitive to light. The sun shining on this small device will cause a 100 Hz tone to wake you in the morning. Or you can use it in many other ways, anywhere you want to sense a light beam. Light left on in the garage? Headlights working? This circuit is the start of interesting ideas. The base of Q1 is not connected to anything. The speaker can be any small one and you will find that a small 9V transistor radio battery works well and lasts a long time.

PARTS LIST FOR SUNRISE ALARM CLOCK

C1—0.1-uF capacitor, 15 VDC
C2—6.8-uF capacitor, 15 VDC
C3—2-uF capacitor, 15 VDC
D1—1N4001 diode
IC1—4011 quad NAND gate
Q1—FPT100 phototransitor
Q2—2N4403
R1—300,000-ohm resistor
R2—15,000-ohm resistor
R3—150,000-ohm resistor
R4—220-ohm resistor
R5—1,000-ohm, resistor

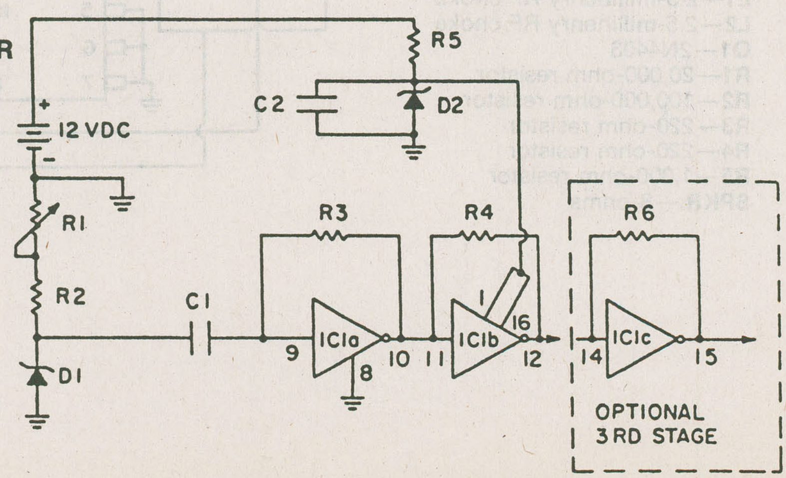


RF NOISE GENERATOR

The diode-generated radio-frequency noise has such a wide spectrum of energy that it can be detected by both long and short-wave receivers. Bringing a transistor radio near the circuit shown below will demonstrate the power and limitations of the generator. The noise generator may be used in checking out a defective receiver through RF and IF stages by injecting it at various points. In the circuit, RF amplification was provided by running CMOS inverters in a linear mode. To reduce heating, an operating potential of about five volts was established through the use of a 1N751 zener diode, functioning normally, and not a noise generator in its own right, we hope!

PARTS LIST FOR RF NOISE GENERATOR

C1,C2—0.1-uF capacitor, 15 VDC
D1—1N758 or 1N759 diode
D2—1N751 diode
IC1—4009A hex buffer
R1—500,000-ohm linear-taper potentiometer
R2—10,000-ohm, resistor
R3 R4—1,000,000-ohm, resistor
R5—300-ohm, 1-watt resistor
R6—1,000,000-ohm, resistor

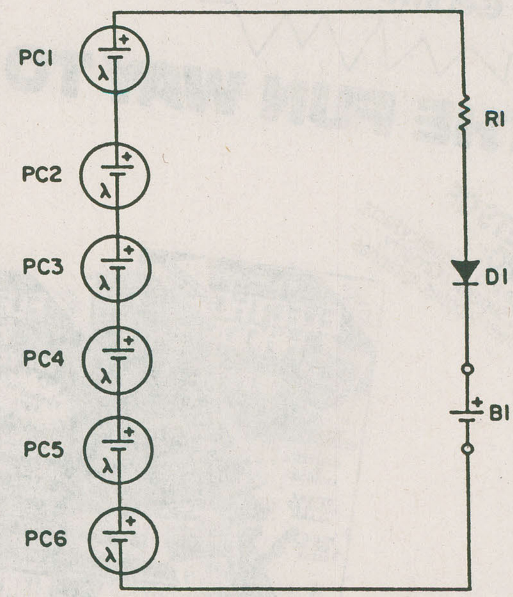


SOLAR BATTERY CHARGER

Tired of charging your NiCd cells? Then let Old Sol do the work for you free-of-charge. In this circuit, photovoltaic cells supply the charging current, which is limited to a safe level by R1. Diode D1 prevents the battery from discharging through the solar cells during periods of darkness.

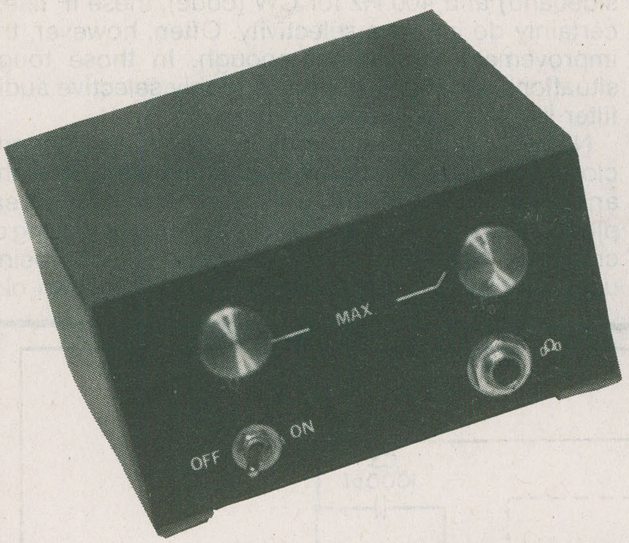
NiCd cells of different sizes require different maximum charging currents for best results. Currents in excess of the recommended values result in rapid evolution of oxygen gas within the cell. When this happens, oxygen gas pressure is relieved through vents, and a significant portion of the cell's chemical contents may be lost in the process. The net effect is reduced cell life; therefore, resistor R1 should be selected to limit the charging current to a safe level.

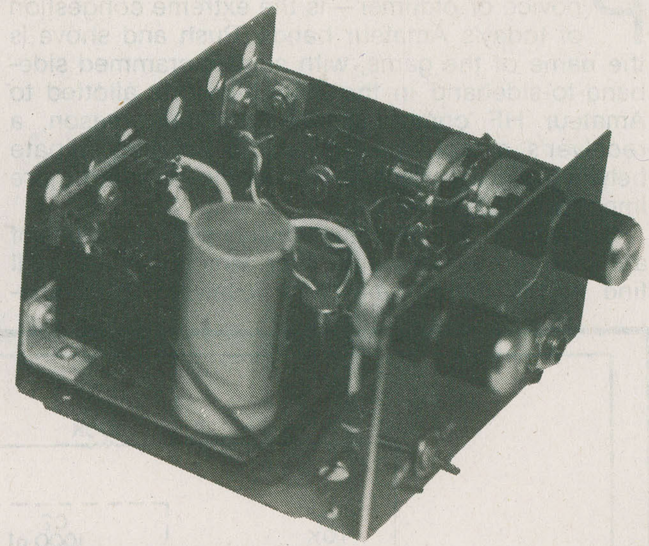
To do this, break the circuit and insert a DC milliameter in series with B1. (Watch those polarities!) Expose the solar cells to the brightest sunshine they can expect to receive, and make note of the charging current. The recommended charging rates for various NiCd cells are: 50 mA for AA cells, and 100 mA for C or D cells. To obtain these currents, the suggested values of R1 are approximately 18 ohms (for AA cells) and 9.1 ohms (for C or D cells). With your milliameter, measure the actual charging current produced by your circuit with the resistor appropriate to your chosen cell size. If the current exceeds the safe level, replace R1 with a larger resistance. As a final note, be sure to select solar cells capable of supplying the desired charging current.



PARTS LIST FOR SOLAR BATTERY CHARGER

B1—1.25V rechargeable NiCd battery
D1—1N4001 rectifier diode
PC1 thru PC6—.5-volt silicon photovoltaic cell (see text)
R1—current-limiting resistor (see text)





SELECTIVE AUDIO FILTER

By Walter Sikonowiz

If you have reached the limit of your endurance from the interference of background noise and/or competing signals on your receiver, this project was designed for you. This audio filter will increase any receiver's selectivity with no internal modifications.

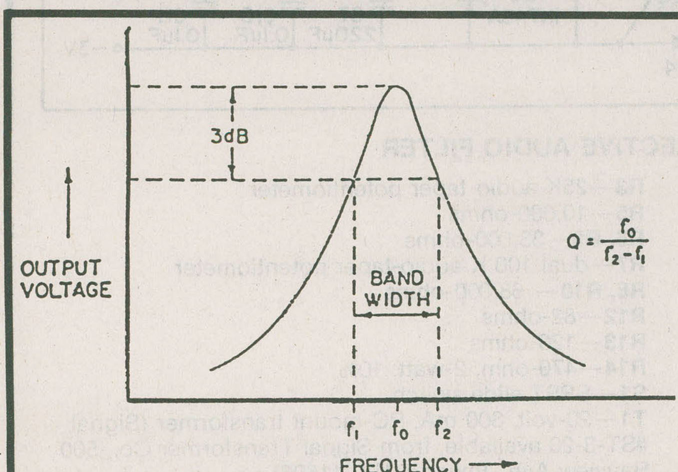


Figure 1. Typical bandpass filter response. Note how the output drops as it moves away from the center frequency (fo).

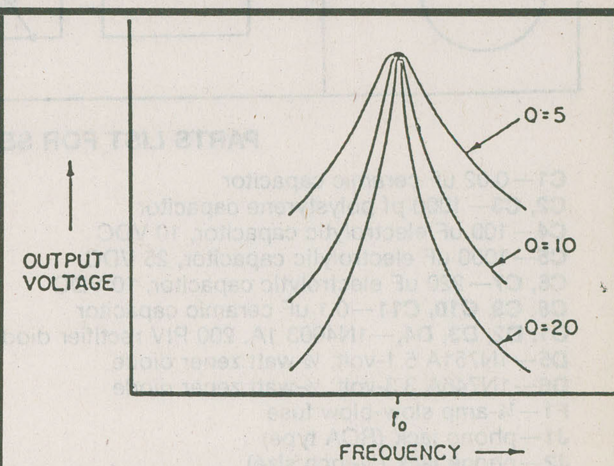
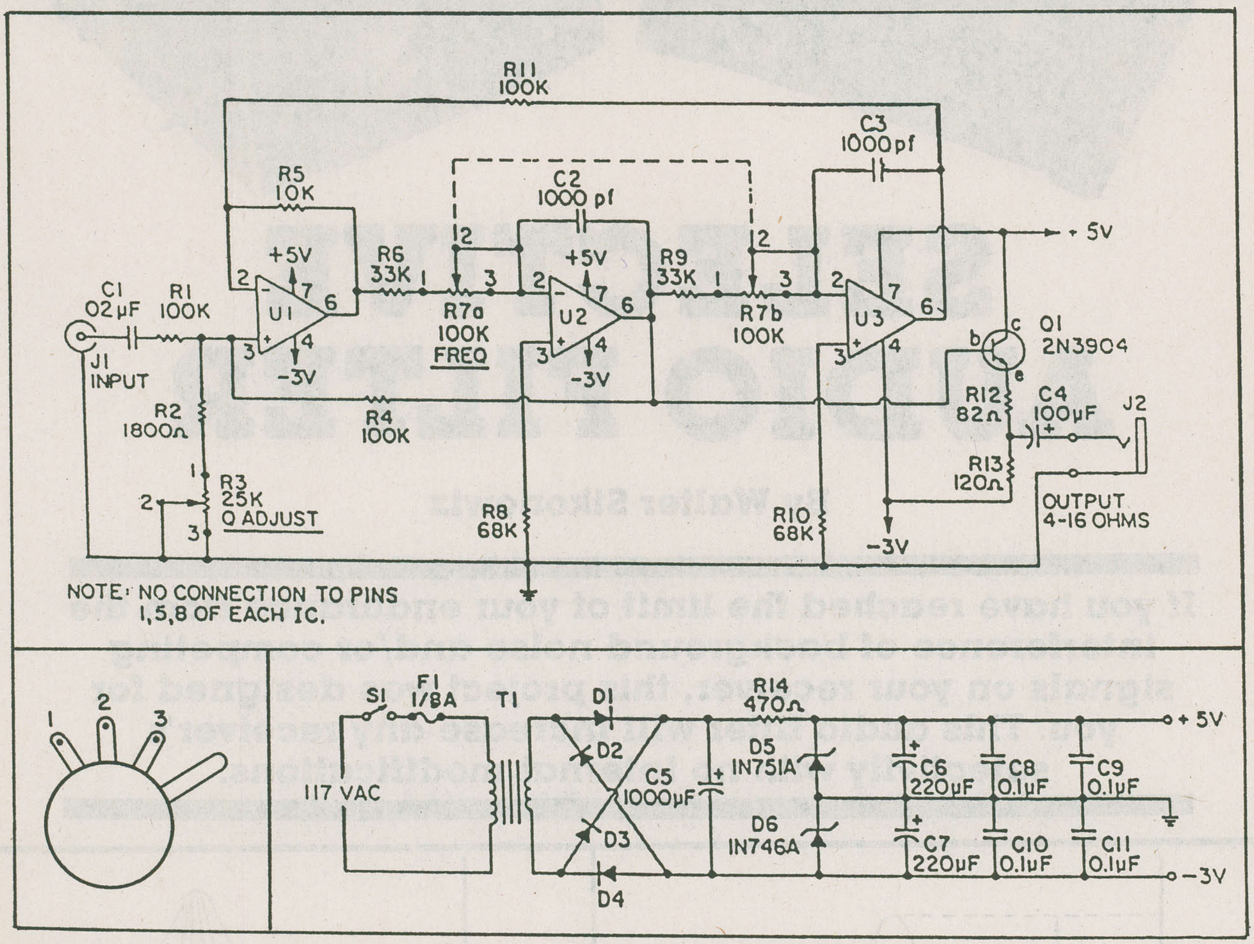


Figure 2. The higher the Q value of the filter, the narrower its bandwith will be. Obviously, a filter with a Q of 20 will have a narrower bandwith than one with a Q of 5.

Probably the biggest headache for any ham— novice or oldtimer—is the extreme congestion of today's Amateur bands. Push and shove is the name of the game, with signals crammed sideband-to-sideband in the 3500 kiloHertz allotted to Amateur HF communication. For this reason, a receiver's selectivity—its ability to discriminate between signals close in frequency—is often more important than its sensitivity.

One way to get better selectivity involves the use of a crystal or mechanical IF filter, which is what you'll find in the better ham-band receivers and transceivers. With bandwidths of 2500 Hz for SSB (single sideband) and 400 Hz for CW (code), these IF filters certainly do improve selectivity. Often, however, the improvement is just not enough. In those tough situations, what you need is a highly selective audio filter like the one presented here.

Not only will this active filter help you to separate closely spaced signals, but it will eliminate most of the annoying background noise as well. It's a real pleasure to copy a clean CW signal without hissing or cracking, especially when headphones are being used. If you're a newcomer getting by with an old,



PARTS LIST FOR SELECTIVE AUDIO FILTER

C1—0.02 uF ceramic capacitor
C2, C3—1000 pf polystyrene capacitor
C4—100 uF electrolytic capacitor, 10 VDC
C5—1000 uF electrolytic capacitor, 25 VDC
C6, C7—220 uF electrolytic capacitor, 10 VDC
C8, C9, C10, C11—0.1 uF ceramic capacitor
D1, D2, D3, D4,—1N4003 1A, 200 PIV rectifier diode
D5—1N751A 5.1-volt, ½-watt zener diode
D6—1N746A 3.3-volt, ½-watt zener diode
F1—⅛-amp slow-blow fuse
J1—phono jack (RCA type)
J2—phone jack (¼-inch size)
Q1—2N3904 NPN transistor
All resistors ½-Watt, 5% Unless Noted Otherwise
R1, R4, R11—100,000-ohms
R2—1800-ohms
R3—25K audio-taper potentiometer
R5—10,000-ohms
R6, R9—33,000-ohms
R7—dual 100 K audio-taper potentiometer
R8, R10— 68,000-ohms
R12—82-ohms
R13—120-ohms
R14—470-ohm, 2-watt, 10%
S1—SPST slide switch
T1—20-volt, 300 mA, PC-mount transformer (Signal #ST-3-20 available, from Signal Transformer Co., 500 Bayview Ave., Inwood, NY, 11696)
U1, U2, U3—RCA CA3140 op amp (available from Circuit Specialists, Box 3047, Scottsdale, AZ 85257)
Misc.—aluminum cabinet, line cord, IC sockets, knobs, etc.

inexpensive receiver, wait until you try this filter. But even with the fanciest rig around, you'll notice a dramatic improvement in selectivity.

Before examining the details of this circuit, let's talk about the selectivity (sharpness) of a band pass filter. Fig. 1 shows a graph of filter output voltage versus frequency. Here it is assumed that the input signal is a sine wave of varying frequency but constant amplitude. As you can see, the output voltage reaches a maximum at f_0 called the center frequency and drops off as frequency is increased or decreased relative to f_0. At frequencies f_1 and f_2, the output has dropped 3 dB (decibels) below its maximum value, that is, to about 70% of the peak voltage at f_0. The filter is said to have a -3dB bandwidth equal to f_2 minus, f_1, as indicated on the graph. The narrower the bandwidth, the more selective the filter will be in operation.

All About "Q"

Another more convenient measure of selectivity is *Q*. To specify our bandpass filter's *Q*, just divide its center frequency by its -3 dB bandwidth. For example, if the center frequency is 1000 Hz and the -3 dB bandwidth is 200 Hz, the filter has a *Q* of 5. Note that *Q* is a dimensionless number. Higher *Q*s will obviously result in more selective filtering, as can be seen from the graph of Fig 2. While high-*Q* filters are desirable from the standpoint of selectivity, "ringing" will limit the amount of *Q* that can be used.

Electrical-circuit ringing is similar to the familiar mechanical ringing of a bell: Each time that a bell is struck, its sound lingers for a noticeable period of time after the blow that initiated it. In like manner, a high-*Q* filter continues to emit a tone (with frequency equal to f_0) whenever the input signal abruptly drops to zero. Since Morse code is a sequence of sound bursts interspersed with silence, the ringing of a very-high-*Q* filter will be apparent after every dit and dah. This has the effect of slurring characters together, making them difficult to interpret. Therefore, we need to compromise and use only enough *Q* to improve selectivity without introducing noticeable ringing.

The bandpass filter presented here can be adjusted to *Q* values between 1.4 and 15. In addition, its center frequency may be adjusted independently of *Q* between 375 and 1500 Hz. Using signals from your receiver's headphone jack as input, the filter is capable of driving low-impedance (4- to 16-ohm) headphones directly. The maximum input signal should not exceed 2-volts peak-to-peak, a level sufficient to produce deafening headphone volume.

The Circuit

The type of bandpass circuit shown in the schematic goes by a variety of names: universal, bi-quadratic or state-variable. While there are simpler ways of constructing a bandpass filter, the state-variable approach works better than most. Note that this is an *active* bandpass filter. Instead of a resonant network of inductors and capacitors, this filter is composed of op amps together with resistors and capacitors. No inductors are necessary with this type of circuit.

Signals from the receiver's headphone jack are coupled into the filter through C1 and R1. Potentiometer R3 controls the *Q:* minimum resistance produces maximum *Q*, and vice versa. R3 is an audio-

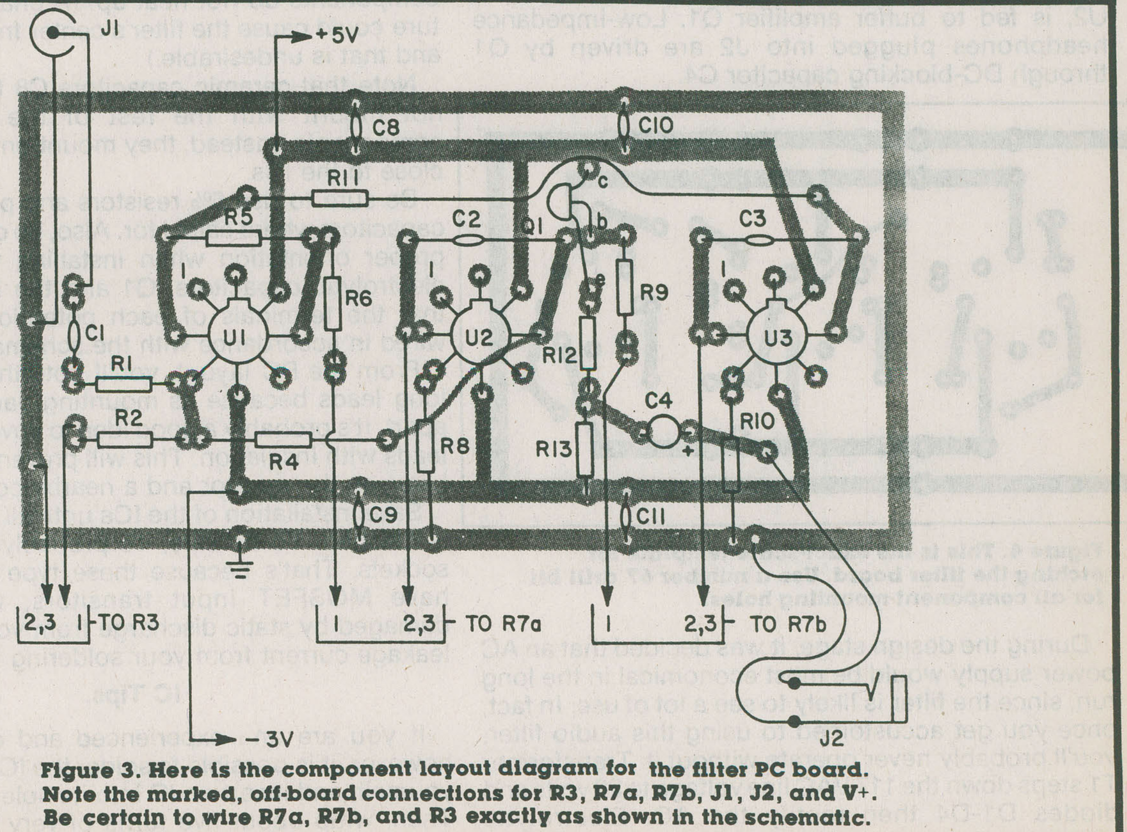


Figure 3. Here is the component layout diagram for the filter PC board. Note the marked, off-board connections for R3, R7a, R7b, J1, J2, and V+. Be certain to wire R7a, R7b, and R3 exactly as shown in the schematic.

taper device whose terminals (1, 2 and 3) must be wired exactly as specified in the schematic. This is necessary to produce a smooth, linear variation in *Q* as the potentiometer is rotated.

Wired as shown, the potentiometer will produce maximum *Q* when fully conterclockwise, and minimum *Q* when clockwise. This is contrary to the norm of having the maximum of any variable in the clockwise position, but you can easily live with it. Actually, a potentiometer with a reverse-logarithmic taper rather than the standard audio taper would produce maximum *Q* in the clockwise position, but such devices are very hard to find. (Note: If by some unexpected windfall you should locate reverse-log-taper pots, interchange the wiring of terminals 1 and 3 from what is shown in the schematic.)

The three op amps are interconnected by several feedback loops to produce the desired bandpass response. First, there are three simple negative-feedback loops; R5 around U1, C2 around U2, and C3 around U3. Then two more negative-feedback loops connect U2 with U1 (through R4) and U3 with U1 (through R11). Needless to say, the interaction among these op amps is very complex, and we won't dwell any further on it.

The center frequency of this filter can be adjusted by R7, a dual audiotaper potentiometer that, like *Q* control R3, must be wired exactly as specified in the schematic. Since maximum frequency occurs when both sections of the potentiometer have minimum resistance, fully clockwise rotation will produce a minimum center frequency, and fully CCW rotation will produce the maximum. Again, this is the reverse of the norm, but you'll get used to it.

The bandpass-filtered output, available at pin 6 of U2, is fed to buffer amplifier Q1. Low-impedance headphones plugged into J2 are driven by Q1 through DC-blocking capacitor C4.

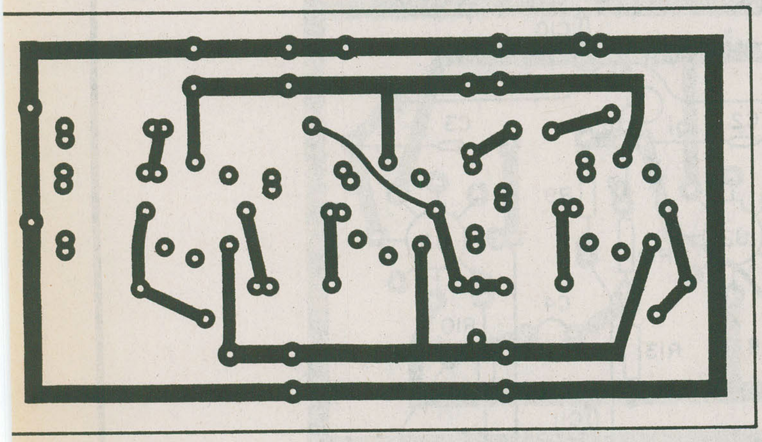


Figure 4. This is the exact-scale template for etching the filter board. Use a number 67 drill bit for all component-mounting holes.

During the design stage, it was decided that an AC power supply would be most economical in the long run, since the filter is likely to see a lot of use. In fact, once you get accustomed to using this audio filter, you'll probably never operate without it. Transformer T1 steps down the 117 VAC line voltage to 20 volts and diodes D1-D4 then rectify the AC. Electrolytic capacitor C5 filters the rectified AC to DC. Then zener diodes D5 and D6, together with current-limiting resistor R14, split and regulate the DC, yielding +5V and −3V outputs. Finally, bypass capacitors C6 through C11 help to keep the supply's output impedance low.

Construction

Construction should be easy, but be careful nevertheless. An aluminum cabinet like the 4×4×2 inch LMB minibox used for the prototype is recommended for the sake of shielding. The chassis should be connected to circuit ground, and this is easily accomplished at the input or output jack. Because of the cabinet's small size, the circuit was laid out on two separate PC boards—one for the power supply and one for the filter. This allowed the cabinet's interior space to be used more efficiently. If you do not like working in tight quarters, however, feel free to use a larger cabinet.

Note that a PC-mounting 20-VAC transformer was used for T1. This unit has the advantage of small size, and it may be ordered directly from the manufacturer. The transformer's pins are inserted into the printed circuit and soldered just as a resistor or capacitor's leads would be. Resistor R14 has a 2-watt rating; do not use a half-watt resistor because it will overheat. If you cannot locate a 470-ohm 2-watt unit, three 1500-ohm ½-watt resistors in parallel will yield an equivalent resistance of 500 ohms with a power rating of 1.5 watts. This is an acceptable substitute. Note the ¼-inch-diameter vent holes that were drilled into the back and bottom sides of the prototype's cabinet. These allow for the circulation of air so that the filter's components do not heat up. (A change in temperature could cause the filter's center frequency to drift, and that is undesirable.)

Note that ceramic capacitors C8 through C11 do not mount with the rest of the power supply components. Instead, they mount on the filter board, close to the ICs.

Be sure to use 5% resistors and polystyrene (5%) capacitors where called for. Also, be certain to get the proper orientation when installing the diodes, the electrolytic capacitors, Q1 and the ICs. Remember that the terminals of each potentiometer must be wired in accordance with the schematic.

From the PC layout, you'll note that R11 requires long leads because its mounting pads are quite far apart. It's probably a good idea to cover this resistor's leads with insulation. This will prevent a short circuit between the resistor and a nearby component.

Save installation of the ICs until all other soldering is finished. To be safe, it's probably best to use IC sockets. That's because these type 3140 op amps have MOSFET input transitors, which can be damaged by static discharge from your fingertips or leakage current from your soldering iron.

IC Tips.

If you are an experienced and careful worker, however, it is possible to solder the ICs. First, ground yourself, and insert an IC into its holes on the board. Then, wrap about five turns of very thin, bare wire

around the IC's leads so as to short them all together. You can now solder using a low-leakage, grounded iron. Do not unwrap the shorting wires until every last connection has been soldered. But don't forget to unwrap the wires, or your circuit will not work. If all this sounds complicated to you, stick with sockets. As a final note, be sure to use only resin-core solder and a small iron—not a soldering gun—to make all of your soldered connections.

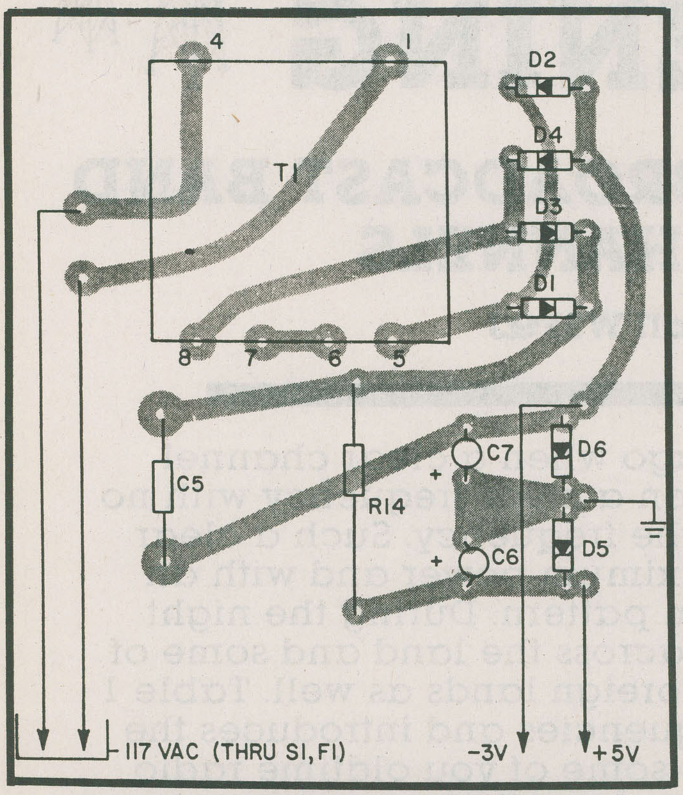


Figure 5. The component layout for the power supply board. Be sure to observe the proper polarity of all diodes and capacitors.

Checkout

That wraps up construction. Double-check your wiring, and then apply power. With a VOM, measure the two supply voltages. If these are in the ballpark, proceed to apply a sine-wave signal of, say 1000 Hz to the filter's input. Make sure that the peak-to-peak amplitude is less than 2 volts.

Plug your headphones into J2. Set R3 for minimum *Q*, and adjust R7 to maximize the volume of the 1000-Hz tone in your headphones. If necessary, reduce the amplitude of the input to produce comfortable headphone volume. Vary the frequency of your signal generator above and below 1000 Hz, and note the gradual decrease in volume that occurs as the input deviates from 1000 Hz. Return your signal generator to 1000 Hz, then increase your filter's *Q* with R3. Once again, rock the signal generator's frequency control around 1000 Hz. With high *Q* you'll notice a much more rapid drop in volume as the input frequency is shifted. (Note: Those who don't own an audio signal generator can skip the above test. However, if the filter fails to improve receiver selectivity, as detailed below, you may need to troubleshoot the circuit. In that case, the above information will be helpful.

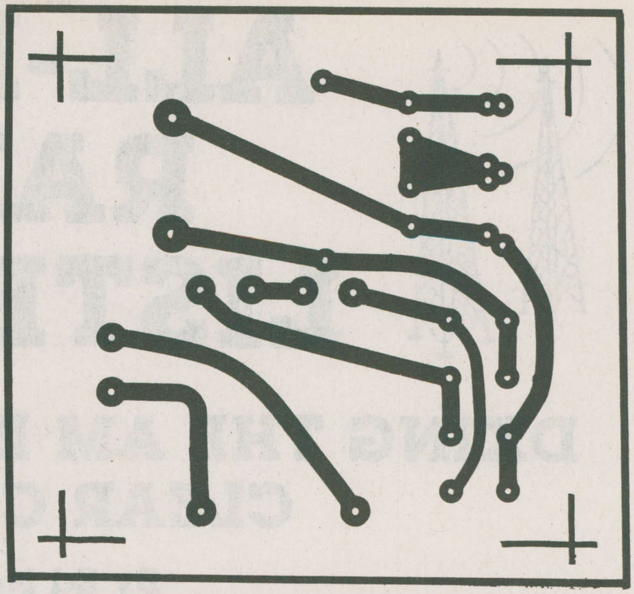


Figure 6. The PC artwork for the power supply board is shown here. As with the filter board, allow room along the edges for drilling holes for the chassis-mounting screws.

Tuneup

If everything checks out OK, the filter is now ready for use with your receiver. To tune things up, you will need a source of unmodulated RF. The best signal is a steady one such as that from an RF generator. Couple it very loosely to the receiver's antenna jack. The marker signal from a crystal calibrator is another excellent choice. If your receiver can tune outside the ham bands, you might even use the unmodulated carrier signal from WWV (at 2.5, 5, 10 or 15 MHz).

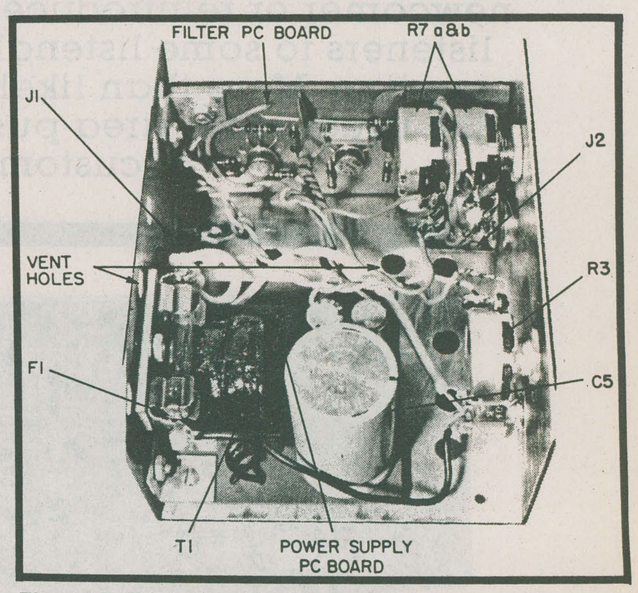
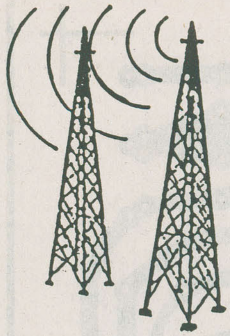


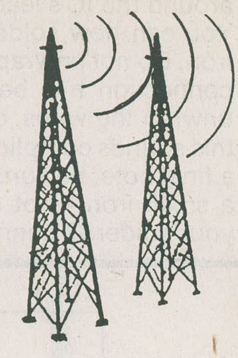
Figure 7. This photograph shows the physical layout of the filter's chassis. It's important that you drill ventilation holes where shown, to avoid frequency drift caused by overheating.

Apply power to both the receiver and the RF signal source. Set the receiver for CW reception, and tune it to the source's frequency (any convenient value). Do

(Continued on page 96)



ALL-BAND RADIO LISTENING



DXING THE AM BROADCAST BAND CLEAR CHANNELS

By Ed Noll W3FQJ

There was a time years ago when a clear channel station really broadcasted on a clear frequency with no other stations on or near the frequency. Such a clear station transmitted at maximum power and with an omnidirectional radiation pattern. During the night hours they could be heard across the land and some of their signals travelled into foreign lands as well. Table 1 lists the clear channel frequencies and introduces the newcomer or reintroduces some of you oldtime radio listeners to some listenable long distance nightime reception. More than likely, it will take you away from the usual local area push-button listening you are accustomed to today.

THIS MODEST COST (R-2000) KENWOOD IS IDEAL FOR DXING BOTH SHORTWAVE (SWB) AND BROADCAST (BCB) AND LONGWAVE (LW) Listening.

Today each clear channel frequency is occupied by more than one station. Usually there is one high-powered dominant station that operates at maximum power of 50 kilowatts and has an omnidirectional radiation pattern. However, there are also a few, sometimes, numerous so-called "drop-in" stations on the same clear frequency. These "drop-in" stations operate with lower power and have directional patterns so as to minimize interference with the dominant clear station. Often "drop-ins" are daytime only stations. Their signals travel a limited distance to serve a restricted local or regional area. Signals would travel farther at night but they may interfere with the dominant clear station(s) on the same frequency.

Other clear channel frequencies are occupied by two and sometimes three high-powered well-separated stations. One of them usually, but not always, is a dominant omnidirectional station while the other one or two stations will have directional characteristics that protect the primary service area of the dominant station from interference.

U.S.A. CLEAR (50 KW) 24-HOUR STATIONS

KHZ	CALL	CITY	STATE	KHZ	CALL	CITY	STATE
640*	KFI	Los Angeles	CA	1030	KTWA	Casper	WY
650*	WSM	Nashville	TN	1040*	WLLO	Des Moines	IA
660*	WFAN	New York	NY	1060	KYW	Philadelphia	PA
660	KTNN	Window Rock	AZ	1070	KNX	Los Angeles	CA
670*	WMAQ	Chicago	IL	1080	WTIC	Hartford	CT
680	WRKO	Boston	MA	1080	KRLD	Dallas	TX
700*	WLW	Cincinnati	OH	1090	WBAL	Baltimore	MD
710	WOR	New York	NY	1090	KAAY	Little Rock	AR
710	WGBS	Miami	FL	1090	KING	Seatle	WA
710	KIRD	Seattle	WA	1100*	WWWE	Cleveland	OH
720*	WGN	Chicago	IL	1100	KFAY	San Francisco	CA
720	KDWN	Las Vegas	NV	1110	WBT	Charlotte	NC
750*	WSB	Atlanta	GA	1110	KFAB	Omaha	NE
760*	WJR	Detroit	MI	1120*	KMOX	St. Louis	MO
760	KFMB	San Diego	CA	1120	KPNW	Eugene	OR
770*	WABC	New York	NY	1130	KWKH	Shreveport	LA
770	KOB	Albuquerque	NM	1130	WNEW	New York	NY
780*	WBBM	Chicago	IL	1140	WRVA	Richmond	VA
780	KROW	Reno	NV	1140	KRAK	Sacramento	CA
810	WGY	Schenectady	NY	1160*	KSL	Salt Lake City	UT
810	KGO	San Francisco	CA	1170	KVOO	Tulsa	OK
820*	WBAP	Fort Worth	TX	1180*	WHAM	Rochester	NY
830*	WCCO	Minneapolis	MN				
840*	WHAS	Louisville	KY	1190	WOWO	Fort Wayne	IN
850	KOA	Denver	CO	1190	KEX	Portland	OR
850	WHDH	Boston	MA	1200*	WOAI	San Antonio	TX
870*	WWL	New Orleans	LA	1210*	WCAU	Philadelphia	PA
880*	WCBS	New York	NY	1500	WTOP	Washington	DC
880	KRVN	Lexington	NE	1500	KTSP	St Paul	MN
890*	WLS	Chicago	IL	1510	WLAC	Nashville	TN
1000	WCFL	Chicago	IL	1510	KGA	Spokane	WA
1000	KOMO	Seattle	WA	1520	KOMA	Oklahoma City	OK
1020*	KDKA	Pittsburgh	PA	1520	WWKB	Buffalo	NY
1020	KBCQ	Roswell	NM	1530	WCKY	Cincinnati	OH
1020	KTNG	Los Angeles	CA	1530	KFBK	Sacramento	CA
1030	WBZ	Boston	MA	1540	WPTR	Albany	NY
1030	KCTA	Corpus Christie	TX	1540	KXEL	Waterloo	IA

TABLE #1. This is a list of the clear channel frequencies. Each is a high-powered station...usually a single (50 KW) station. Where 2 or 3 stations are on the same frequency, they are separated by substantial geographical distances.

What is attractive about clear channel DXing is the ease with which some long distance stations can be heard. At the same time you can have some fun trying to tune in some of the drop-ins on each frequency if you are not too near the dominant station. Some evening, sit down in front of a reasonably good AM receiver with an accurate and readable dial calibration and give a listen. Try out this type of DXing. Of course the receiver with a digital read-out is the most attractive because you can easily set the receiver to a desired clear frequency.

Table 1 lists the FCC clear channels and the 50 KW high-powered stations assigned to these frequencies. Note that most of them have only a single 50 KW station. Others have two or three 50 KW stations separated by substantial geographical distances. The high-powered clear channel stations have been a tradition in American broadcasting. I think it would be unwise if the broadcast industry and the FCC frittered them away. Most of them came on the air in the twenties. Their years of pioneering broadcast service deserves an exclusive frequency assigment. When you listen to a clear-channel station today you have also tuned into the early days of broadcasting. They are a boon to stereo transmission because they can serve a much greater nighttime area than any FM station. Certainly you will never hear me classify any high-powered clear-channel broadcast station as a pest.

The stations listed in Table 1 are all "clears" that can broadcast 24 hours a day with the maximum permissible 50,000 watts. **White's Radio Log** is a useful low cost book for the new broadcast band (BCB) listener. It lists the stations of Table 1 as well as many of the lower-powered drop-in stations on each frequency. In fact there is a detailed listing of assignments on all the broadcast channels between 540 and 1600 KHZ. FCC frequency assignments are spaced 10 KHZ apart over this spectrum. White's Log also covers FM and TV stations as well as key shortwave broadcast stations. Purchase address is **White's Radio Log ($4.95+$1.50 P&H), P.O. Box 5148, North Branch, New Jersey 08876.**

Those 26 clear channel frequencies marked with an asterisk, Table 1, are the original old-time maximum protection assignments. At one time one and only one station was assigned to each frequency and, on winter nights when propagation was right, most could be received coast to coast. Today the dominant station on each frequency operates with an omnidirectional pattern with the exception of 870, 1020, 1100 and 1190. WWL (870) New Orleans has a pattern that is directed stateside away from the Gulf of Mexico. Likewise WBZ Boston directs its signal landward. Both WWWE Cleveland and KFAX San Francisco on 1100 use directional patterns as do WOWO Fort Wayne and KEX Portland on 1190. Such considerations minimize the interactions between two high-powered stations operating on the same frequency. Of course there are small or large groupings of low-powered "daytime only" and low-powered "day and night" directional stations on these 26 frequencies as well. However, the number of assignments are not nearly so great as those on the

many regional and local FCC frequency assignments to be covered in future columns. Consequently the "clears" give you an opportunity to gain some DXing experience before you tackle some of the much more crowded frequencies.

It is a good first time activity for a new BCB listener or something in the way of a different project for a more experienced BCB listener to concentrate on these frequencies for a period of time. Find out what you can do on these first clear channel frequencies. My results for several days are shown in Table 2. For most frequencies the results will not be the same each day. Of course the strong dominants or other close-by locals will stay the same day after day. For many of the other channels and in particular during the sunset and nightime hours, there will be changes from season-to-season, night-to-night and often hour-by-hour. A mix (marked MX on Table 2) on a frequency is often common during which time there may be two or three weak signals on a frequency and you are not able to identify any one of them immediately. Some time I'll do a story on how to handle mixes and make several identifications of stations operating on the same frequency. On occasion, a frequency will be dead one night and have a good signal present there the next evening.

FREQ.	SUNRISE 7:30-9AM	NOON 11-12:30	SUNSET 4:30-6:30	EVENING 7-9:30	NIGHT 9:30-M
640	WNNV	—	—	MX	MX
650	MX	—	WSM	WSM	WSM
660	WFAN	WFAN	WFAN	WFAN	WFAN
670	WMAQ	—	WMAQ	WMAQ	WMAQ
700	WLW	—	WLW	WLW	WLW
720	WWII	WWII	MX	WGN	WGN
750	MX	WBMD	MX	WSB	WSB
760	MX	—	MX	WJR	WJR
770	WABC	WABC	WABC	WABC	WABC
780	MX	—	WBBM	WBBM	WBBM
820	MX	WKYC	WOSU	MX	MX
830	WNYC	WNYC	MX	MX	WCCO
840	MX	WVPO	WHAS	WHAS	WHAS
870	MX	—	MX	WWL	WWL
880	WCBS	WCBS	WCBS	WCBS	WCBS
890	WLS	—	WLS	WLS	WLS
1020	KDKA	—	KDKA	KDKA	KDKA
1030	MX	MX	MX	WBZ	WBZ
1040	MX	MX	MX	WHO	WHO
1100	WWWE	—	MX	WWWE	WWWE
1120	MX	—	KKQW	KMOX	KMOX
1160	MX	MX	MX	MX	MX
1180	WHAM	MX	WHAM	WHAM	WHAM
1190	MX	MX	MX	WOWO	WOWO
1200	MX	MX	WAGE	MX	MX
1210	WCAU	WCAU	WCAU	WCAU	WCAU

TABLE #2. This is a typical logging of some of the original clear frequencies in mid-December. A mix (2 or 3 weak signals) is quite common and is identified as "MX" in this table.

No matter where you live, in the continental USA, you can receive a number of the "clears" I receive here in southeastern Pennsylvania on the 26 original clear station frequencies. The same applies to your friends who live in some other parts of the country. They can pick up some of the "clears" that you and I copy. How many of you can pick up WSM Nashville on 650 KHZ? Tune into the Grand Old Opry some Friday or Saturday night. I may be listening too. This is the oldest continuously broadcast radio program in existence.

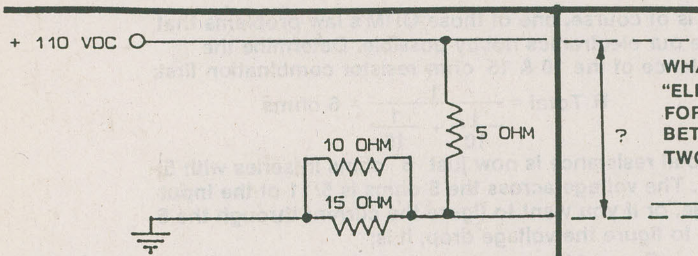
In Table 2 listening was done several times a day. Usually mid-day listening is the same day after day. Likewise early morning listening will be quite uniform during the long-day months of the year (beginning the first day of Spring until the first day of Fall) but more changeable during the short-day months (Fall to Spring). Changes don't occur all that abruptly. It is a gradual changeover that takes place slowly and often wavers back and forth. The dawn and especially the sunset hours throughout the year are good for DXing. So are the early and late night hours.

After you have covered the special "clears", go on to the ten "clears" that remain in Table 1. In general these ten frequencies have more assigned stations and you are likely to have more mixes and difficulty in making identifications. Sunset hour listening can bring many surprises. For example 680 KHZ has about 25 station assignments. Then there is 850 KHZ with more than 30 assignments and most of them are 24-hour stations. If you don't live too near one of the clear stations take on the challenge of making six or more identifications over several months. Actually you can devote an entire winter listening to the "clears" only and enjoy BCB DXing, identification and just plain listening to AM broadcast stations from more distant parts of the USA. If you really want to become a BCB insider, join the National Radio Club, which is devoted to the hobby of AM broadcast band listening. If you would like some additional information, their address is P.O. Box 24, Cambridge Wisconsin 53523. Join us next issue for another venture into all-band radio listening. ■

"THE ELECTROPAGE"

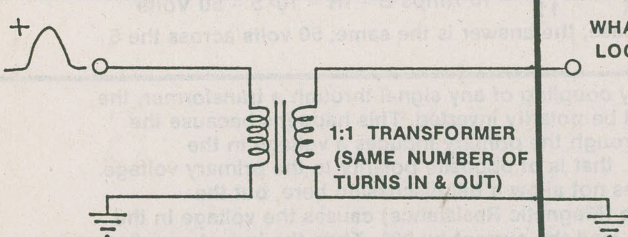
By: Glenn M. Rawlings

Here is a fun way to check your electronic knowledge, or perhaps brush up on some fundamentals — and at the same time you will get some experience at "folding papers". Study each circuit below, notice what the INPUT conditions are as stated.... Your job is to figure out what the OUTPUT VOLTAGE will be for each circuit shown, and then to actually draw a sketch of the output in the blank space to the right.



WHAT IS THE "ELECTROMOTIVE FORCE" (VOLTS) BETWEEN THESE TWO POINTS?

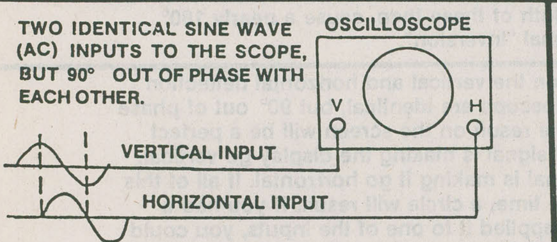
VOLTS



WHAT DOES THE PULSE LOOK LIKE HERE?

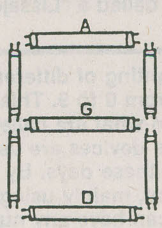
1:1 TRANSFORMER (SAME NUMBER OF TURNS IN & OUT)

TWO IDENTICAL SINE WAVE (AC) INPUTS TO THE SCOPE, BUT 90° OUT OF PHASE WITH EACH OTHER.

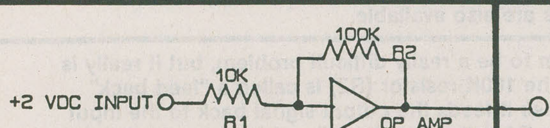


IF THE SCOPE HAS THE SAME VERTICAL/HORIZONTAL GAIN, DRAW PICTURE ON THE SCREEN:

7 FLUORESCENT LITE TUBES ARE ARRANGED IN THE FIGURE "8" CONFIGURATION. IF YOU WANTED TO MAKE THE NUMBER "2", BY LIGHTING THE TUBES, WHICH WOULD YOU TURN ON? CHECK THE BOXES AT RIGHT.



☐ A
☐ B
☐ C
☐ D
☐ E
☐ F
☐ G



WHAT IS THE DC VOLTAGE OUT OF THE OPERATIONAL AMPLIFIER?

TO SEE ANSWERS, FOLD OVER PAGE AT THIS DOTTED LINE

When you have completed all your answers, (and it might be a good idea to check them twice) then and ONLY THEN, fold the page at the dotted line to see how you did.

Some of the answers will be in the form of a plain old DC voltage above or below ground, but on the other hand, some of the outputs will be of a more "dynamic" nature, such as you might see on a piece of test equipment called the Oscilloscope.

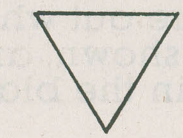
Remember this is just a fun way to check your knowledge, and perhaps learn a little more about the wonderful world that we call electronics. So don't feel bad if you should happen to miss one or two of the answers, at least the first time through! When you completely turn this page, you will find an explanation in detail of each circuit.

HAVE FUN!

LOOK FOR THE ELECTROPAGE IN THE NEXT ELECTRONICS HANDBOOK.

THE ELECTROPAGE

HERE ARE THE ANSWERS TO THE "ELECTROPAGE"!



Congratulations for completing the "ELECTROPAGE". The following explanations may help to clear up some of the answers. While space does not allow a complete coverage of all the details of each circuit or diagram, it is hoped that your appetite has been tempted, to study in more depth some of the principles that have been briefly described. It is the curiosity of how and why things work, that has caused the field of electronics to be where it is at today.

---

50 VOLTS

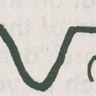
This is of course, one of those OHM's law problems that make our electronics hobby possible. Determine the resistance of the 10 & 15 ohm resistor combination first:

$$R\ \text{Total} = \frac{1}{\frac{1}{10} + \frac{1}{15}} = 6\ \text{ohms}$$

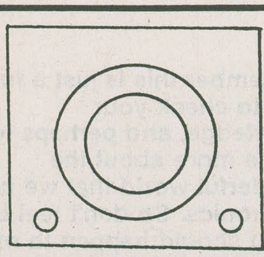
The total resistance is now just 6 ohms in series with 5 ohms. The voltage across the 5 ohms is 5/11 of the input voltage, or if you want to figure the current through the 5 ohms to figure the voltage drop, it is;

$$I = \frac{E}{R} = \frac{110}{11} = 10\ \text{Amps}\quad E = IR = 10\times 5 = 50\ \text{Volts}$$

In either case, the answer is the same; 50 volts across the 5 ohms.



In ordinary coupling of any signal through a transformer, the output will be polarity inverted. This happens because the current through the primary induces a voltage in the secondary that is of opposite polarity to the primary voltage. Space does not allow a full discussion here, but the inductance (Magnetic Resistance) causes the voltage in the primary to lead the current by 90°. Then the inductance that occurs in the secondary of the transformer causes another 90° phase shift. Both of these then cause a nearly 180° phase shift, or signal "inversion".



When the signals on the vertical and horizontal deflection plates of the oscilloscope are identical, but 90° out of phase with each other, the result on the screen will be a perfect circle. The vertical signal is making the display go vertical. The horizontal signal is making it go horizontal. If all of this occurs at the same time, a circle will result. If you had a *known* signal and applied it to one of the inputs, you could match another signal that was unknown, by adjusting it to make a circle. This is called a "Lissajous" figure, the simplest being a circle.

A
B
D
E
G

As you can see, the lighting of different tubes will allow you to make any number from 0 to 9. This is the exactly the same principle that is used in what are called "seven segment display" devices. These devices are used on everything from watches to calculators these days. By having the appropriate signals to each segment, mainly using digital logic to turn them on and off, you can have any number you want. Of course two of them (or more) can be placed side by side. Letter displays are also available.

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20 VOLTS

This may seem to be a really difficult problem, but it really is very simple. The 100K resistor (R2) is called a "feed back" resistor, because it feeds the output signal back to the input partly. Resistor R1 called the "input" resistor because it feeds the input signal to the amplifier. The gain of any amplifier like this is related to the ratio of these two resistors. That ratio is always the feed back resistor divided by the input resistor, in this case 100÷10=10, then 10×2 Volts=20 Volts.

BASIC TUBE RESTORATION

By William Donzelli

If you are an antique radio enthusiast, you have undoubtedly had more than a fair share of experience with old electron tubes. Unfortunately, these tubes, ranging from forty to seventy years old, deteriorate with age and are rapidly becoming an endangered species. They become dirty, the base becomes loose, and the wires break, Don't despair! If you are lucky enough to possess some of these rare gems, they may be salvaged. There are ways to correct these problems that will result in better operation and a neater appearance. In this article, we will explain some basic procedures for the restoration of electron tubes.

Cleaning

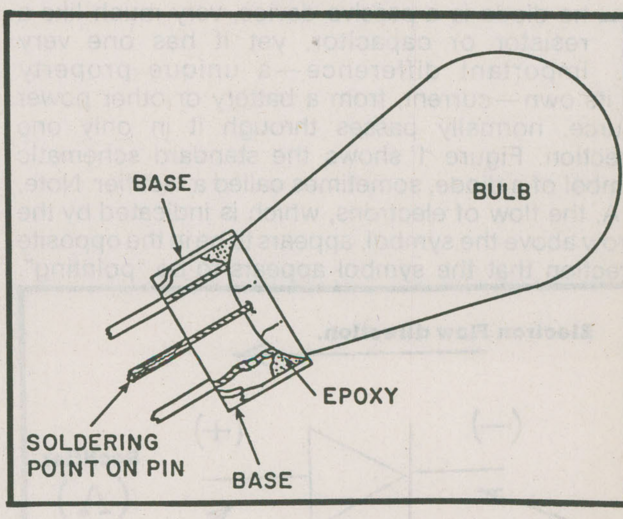
As you probably know, electronic devices tend to collect dirt quickly. Tubes are no exception and they usually accumulate a substantial amount of undesirable material. Cleaning these old tubes is the first and easiest of the restoration process.

The materials needed are Isopropyl Rubbing Alcohol and some cotton balls. The process is simple, although care must be taken or problems could arise. Simply soak the cotton with the alcohol and wipe the tube, changing the cotton when it becomes saturated with dirt. You will observe that some of the discolorations are inside the tube, so don't be fooled by a spot that can not be cleaned.

When cleaning the glass bulb, be very careful not to rub off any ink markings, such as the tube number. The alcohol will dissolve the ink if rubbed vigorously, therefore, *gently* dab the inked area with the cotton. This will loosen the dirt and remove it, but the ink will remain unchanged. After the tube is cleaned and the alcohol evaporated, wipe the tube with a dry cotton ball to remove any smears. If you have been careful, you should now have a clear, neat looking tube.

Fixing Loose Bases

Loose bases are another common problem with old tubes. The combination of heat and age cracks the glue joining the base and the bulb, leaving delicate wires as the only mechanical connection. Obviously, this problem must be corrected or the tube can anticipate further deterioration in the near future.



Mending a loose base is relatively easy, but involves more time and materials than cleaning. You will need some solder and a soldering iron, a hobby knife, epoxy, and desoldering braid. First, remove the old solder from the tube's pins with the braid (see illustration). After the pins are desoldered, gently remove the base, labeling each of the wires and the respective pins. This will be critical when the base is re-attached. Next, remove *most* of the old epoxy with

(Continued on page 96)

UNDERSTANDING SEMICONDUCTORS

By William R. Hoffman

Most of us at one time or another have built some of the projects published in the ELECTRONICS HANDBOOK, or elsewhere; a power supply, or a light dimmer, or any one of a multitude of other projects that have been published. Some of us have also found ourselves wondering about what the semiconductor devices that we commonly use are really like—what's inside them? For others, trying to design and/or fabricate a PC board for a project has been a problem because some of the parts must be measured for their dimensions and lead orientation before proceeding. This short series covering diodes, transistors, and FET's should help the reader have a better understanding of these very important, indeed integral, parts to almost every electronic project.

Start With Diodes

The diode is a passive device, very much like a resistor or capacitor, yet it has one very important difference—a unique property all its own—current, from a battery or other power source, normally passes through it in only one direction. Figure 1 shows the standard schematic symbol of a diode, sometimes called a rectifier. Note, at A, the flow of electrons, which is indicated by the arrow above the symbol, appears to be in the opposite direction that the symbol appears to be "pointing".

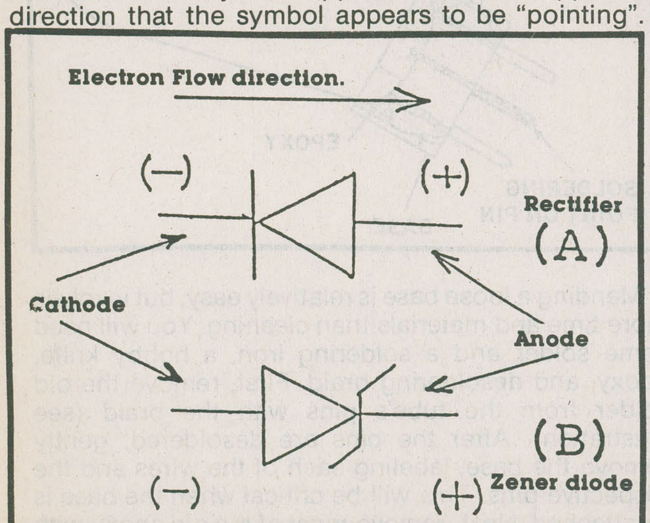


Figure 1. Standard rectifier diode and zener diode symbols.

This is because in the very early days of electricity, when the diode symbol originated, physicists did not understand what electricity really was, and thought that it "flowed" from the positive to the negative. But now, we all know that electricity is a flow of electrons, which have a negative charge and originate at the negative end of a battery and move toward the positive end. Therefore, our diode symbol appears to be backward.

A diode, which conducts in one direction, can only begin to conduct, once a minimum value of voltage is applied; that voltage, for the standard silicon diode, is about 0.5V, or for the earlier germanium type diodes, about 0.25V. Once this minimum voltage is applied in the normal "forward" direction, the diode will begin to conduct freely. See Figure 2.

However, what happens when a diode is subjected to a reverse voltage polarity? As Figure 2 also shows, although in the forward direction, about 0.5V causes the silicon diode to conduct in reverse. It does not have an infinite capacity to resist the force of an applied voltage. At some point the diode will stop blocking, and because of an internal breakdown, allow free and uncontrolled current to flow in the reverse direction. When this happens, the diode is usually destroyed; it shorts internally and appears physically cracked and burned. Therefore, a diode must not be used beyond its reverse voltage rating. In Figure 2, this is shown on the graph at about 50V. Actually, depending on the diode construction, this

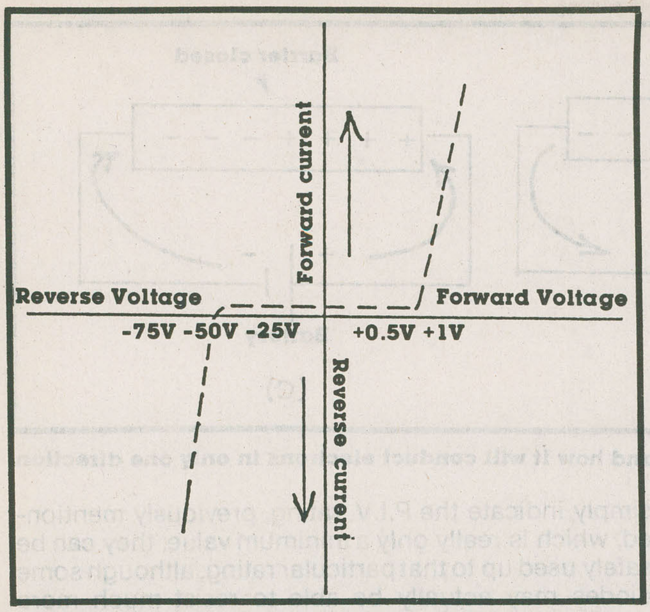


Figure 2. Graph of forward conduction and reverse breakdown characteristics of a typical diode.

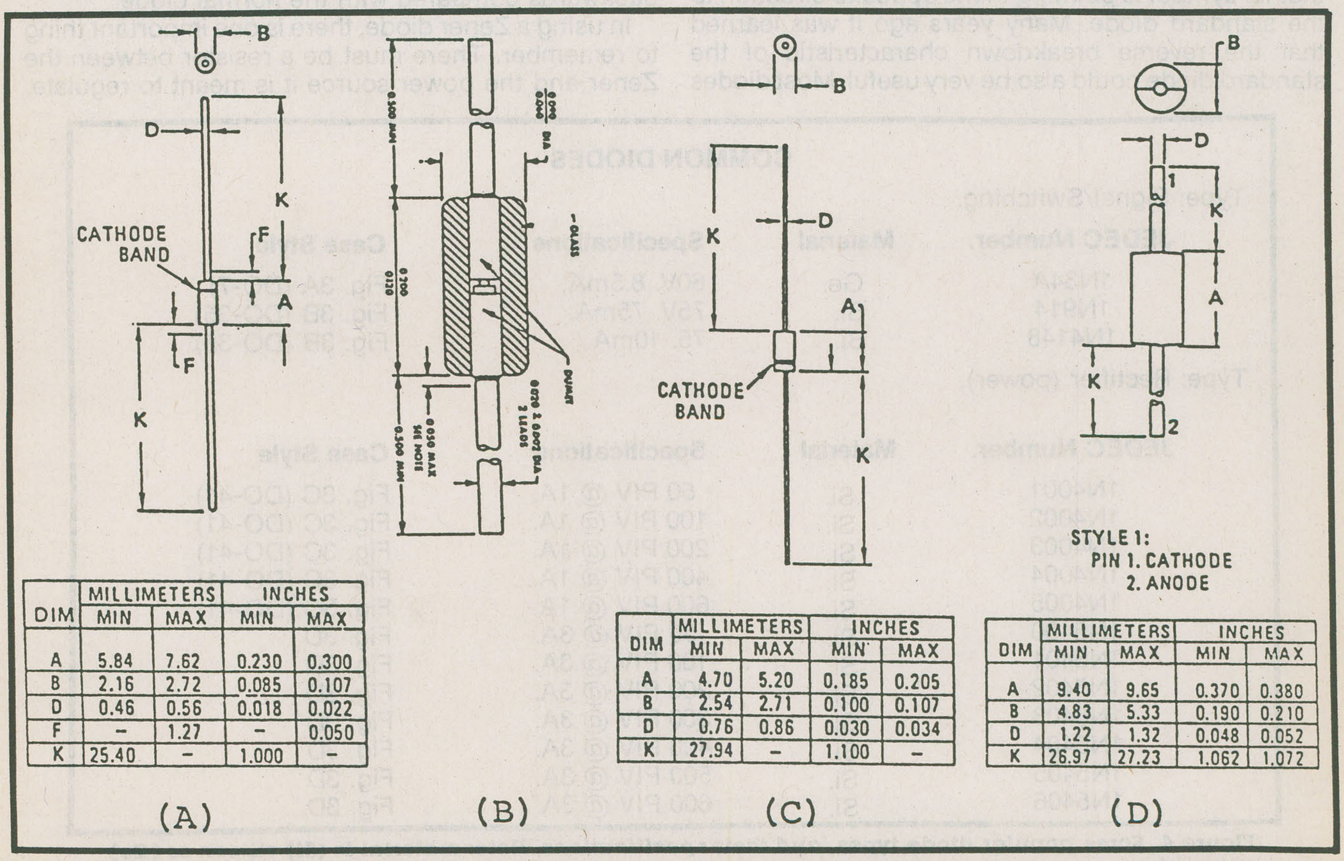
breakdown can take place anywhere from a few volts to several thousand volts, depending on how it is manufactured. This breakdown rating is called the "P.I.V." for Peak Inverse Voltage of the diode.

How A Diode Works

The construction of a diode is really quite simple. In Figure A, Illustration A, we start with just a small bar of very pure silicon (or germanium) which by itself is a very poor conductor. Then, in the manufacturing process, we heat up the bar of material, and surround it with a gaseous material whose atoms contain either an excess of electrons, or negative charges, (like phosphorus) or a shortage of electrons, or positive charges, (like boron), and let them "diffuse" into the material of the bar, one at each end. These create + or Positive regions, and - or Negative regions in the bar.

The key to making this bar a conductor, or having it resist conduction (as an insulator) is very simple. Studying Figure A again, look at Illustration B. Note that there is a battery connected with electrodes at each end of the bar. Because of the polarity of the battery, the Negative charges in the N region have been attracted to the Positive end of the battery, and the Positive charges in the P region have been attracted to the Negative end of the battery. This happens according to Coulombs Law, that states that opposite charges attract each other. The result is that there now exists a region in the middle of the bar (the barrier) where the bar material is just the pure silicon or germanium—which is a very good insulator, and no conducting through the bar is possible.

Going to C in Figure A, we see that the position of the battery has now been reversed, the Positive and Negative ends are opposite to what they were in B above, and things inside the bar are different now. From Coulombs Second Law, that like charges repel each other, we now see that since the Positive end of the battery is connected to the Positive end of the bar, and the Negative battery end to the Negative end of the bar, the charges are forced together in the middle of the bar and the barrier is closed up. Now, with the



(A)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

(C)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	5.20	0.185	0.205
B	2.54	2.71	0.100	0.107
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

(D)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

Figure 3. Case styles and dimensions for the most popular diode types; signal, switching, rectifier, and Zeners

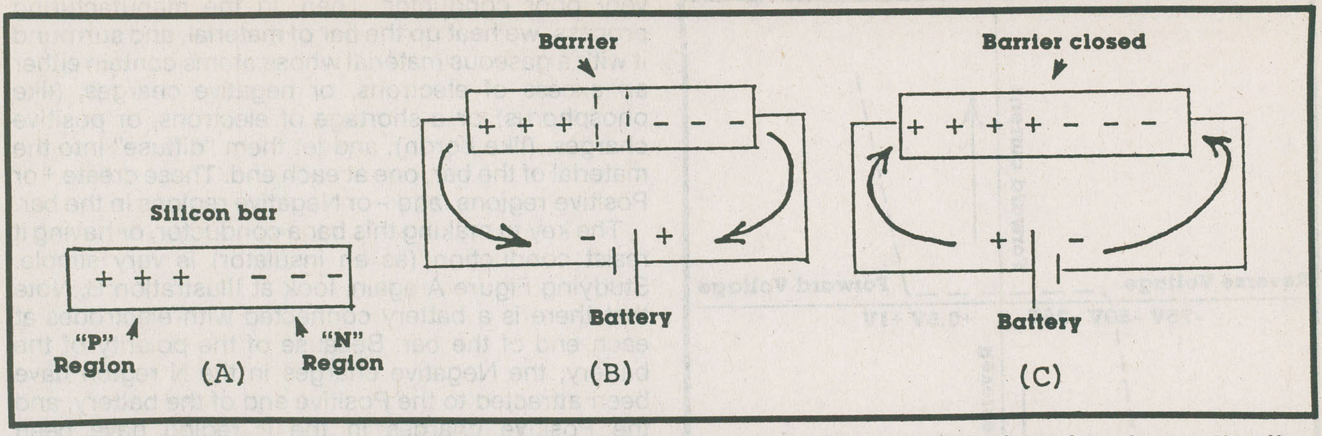


Figure A. Showing how a semiconductor diode is made, and how it will conduct electrons in only one direction

Positive and Negative charges in contact, conduction can begin; the Negative charges are attracted to and will flow through the Positive region, and electrons from the Negative battery terminal will flow through the bar to the other end of the battery completing a circuit. Relating this to Figure 2, the condition with the battery in reverse, or non-conducting state relates to the condition to the left of the vertical center line, which represents current flow; while with the battery in forward conduction direction, relates to the condition to the right of the center line.

The Zener Diode

Going back to Figure 1, at B we have the symbol for a special kind of diode, called a Zener Diode. Note that its symbol is pointing in the opposite direction to the standard diode. Many years ago it was learned that the reverse breakdown characteristic of the standard diode could also be very useful. Most diodes simply indicate the P.I.V. rating, previously mentioned, which is really only a minimum value; they can be safely used up to that particular rating, although some diodes may actually be able to resist much more reverse voltage than their specifications indicate. Nonetheless, if we made a diode with a very carefully controlled breakdown value, and specified it at the time it was sold, we could make use of this breakdown voltage in using the diode to act as a voltage regulator. For instance, a diode that had a breakdown rating of, say, 12V, could be used in a circuit to set the value of a particular voltage to just that value. This carefully controlled reverse breakdown voltage is what makes our diode a Zener type. Since we are using it in reverse, the symbol at B in Figure 1 seems backwards compared with the normal diode.

In using a Zener diode, there is one important thing to remember. There must be a resistor between the Zener and the power source it is meant to regulate.

COMMON DIODES

Type: Signal/Switching.

JEDEC Number.	Material	Specifications	Case Style
1N34A	Ge.	60V. 8.5mA.	Fig. 3A (DO-7)
1N914	Si.	75V. 75mA.	Fig. 3B (DO-35)
1N4148	Si.	75. 10mA.	Fig. 3B (DO-35)

Type: Rectifier (power).

JEDEC Number.	Material	Specifications	Case Style
1N4001	Si.	50 PIV @ 1A.	Fig. 3C (DO-41)
1N4002	Si.	100 PIV @ 1A.	Fig. 3C (DO-41)
1N4003	Si.	200 PIV @ 1A.	Fig. 3C (DO-41)
1N4004	Si.	400 PIV @ 1A.	Fig. 3C (DO-41)
1N4005	Si.	600 PIV @ 1A.	Fig. 3C (DO-41)
1N5400	Si.	50 PIV @ 3A.	Fig. 3D
1N5401	Si.	100 PIV @ 3A.	Fig. 3D
1N5402	Si.	200 PIV @ 3A.	Fig. 3D
1N5403	Si.	300 PIV @ 3A.	Fig. 3D
1N5404	Si.	400 PIV @ 3A.	Fig. 3D
1N5405	Si.	500 PIV @ 3A.	Fig. 3D
1N5406	Si.	600 PIV @ 3A.	Fig. 3D

Figure 4. Some popular diode types, and their specifications. Note: material is (Si) silicon or (Ge) germanium.

COMMON ZENER DIODES

JEDEC Number.	Zener Voltage Rating (±5%)	Case Style
1N4733A	5.1V @ 49mA.	Fig. 3C
1N4734A	5.6V @ 45mA.	Fig. 3C
1N4735A.	6.2V @ 41mA.	Fig. 3C
1N4737A	7.5V @ 34mA.	Fig. 3C
1N4739A	9.1V @ 28mA.	Fig. 3C
1N4742A	12V @ 21mA.	Fig. 3C
1N4744A	15V @ 17mA.	Fig. 3C
1N4749A	24V @ 10.5mA.	Fig. 3C
1N4751A	30V @ 8.5mA.	Fig. 3C
1N4753A	36V @ 7mA.	Fig. 3C
1N4756A	47V @ 5.5mA.	Fig. 3C
1N4757A	51V @ 5mA.	Fig. 3C

Figure 5. Some popular Zener Diode types, and their specifications. All are silicon. 10% tolerance parts have the same JEDEC part numbers, except the suffix "A" is omitted.

Otherwise, when it begins to conduct, it may draw too much current, and overheat and destroy itself.

Other Diode Types

Just as the carefully controlled breakdown makes a regular diode a Zener type, we can also optimize other characteristics for special purposes. Making the diode body large will allow it to handle many amperes of current, such as a power supply or battery charger. When a diode is used like this, to convert alternating current (AC) into direct current (DC), it is also referred to as a rectifier. Also, when acting as a radio detector, or for logic switching in computers, the diode must be made very small—hardly larger than the lead in a wooden pencil—and must be able to switch from "on" in forward conduction, to "off" in reverse, very rapidly. These are called "signals" or "switching" diodes. Finally, another diode type, called a varactor, is made to take advantage of the property of a diode to act like a small capacitor—one that can actually change its capacitance value with the amount of DC voltage applied to it. This is designed to be used in tuned radio circuits, where being able to change the frequency of an oscillator is important to tuning the radio.

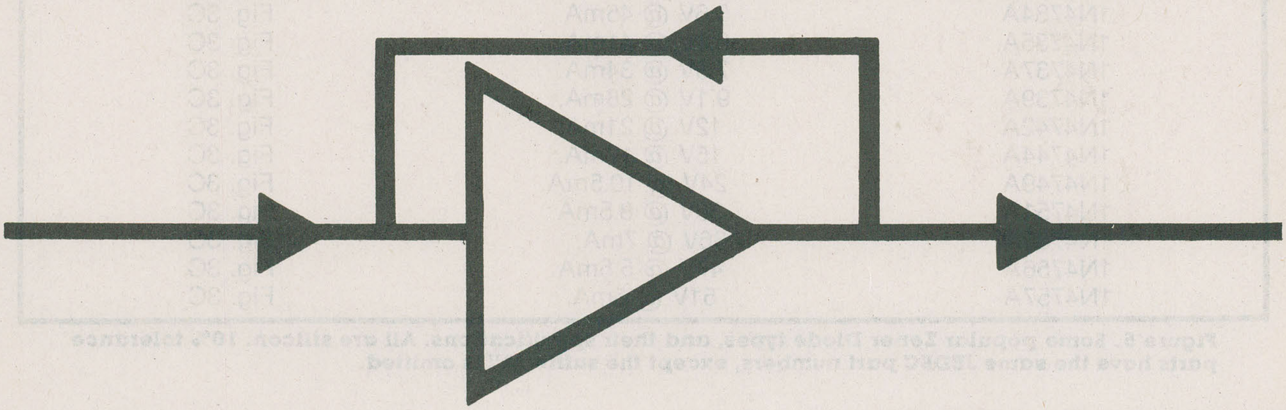
Numbering Diodes

Most diodes are given an alphabetic and numeric part number. Most American made diodes have numbers that begin with 1N-, while Japanese made diodes usually start with 1S-. These numbers are assigned to a particular diode with a specific set of characteristics, that is, any diode with a certain standard type number, regardless of the manufacturer, will have the same characteristics regarding breakdown, voltage, current, etc. All standard American diodes will have a number assigned by JEDEC (Joint Electron Device Engineering Council). Figures 4 and 5 are lists of very popular rectifier, zener, signal, and switching diodes which should be readily available at any electronic supplier or mail order company. Their important specifications are also listed. These lists should provide the experimenter with the most common type diodes likely to be needed in building electronic projects.

Finally, Figure 3 shows the case styles and dimensions of all the most popular diodes—including the dimensions, for those interested in laying out a printed circuit board.

With this information, the reader should have a better understanding of the diode, where it can be used, and how to locate the one you need for a project you may be building. ■

IC TESTBENCH



Of the three projects sections in this issue of Electronics Handbook the ones presented here are the most elaborate, and many require more circuit components than the projects in the other two sections. In addition, most of them employ two or more integrated circuits (ICs).

If you haven't already assembled several of the simpler projects, you should probably select one or more projects from our Circuit Fragments sections first, since the projects in this section are more advanced than the others. We suggest you study them carefully before deciding which one to put together. Once you've made a choice, copy the circuit onto a new sheet of (larger) paper, and study it until you understand each part of it perfectly. When you've done that, you can finally get all the components together and start the assembly.

TOUCH-SENSITIVE KEYBOARD

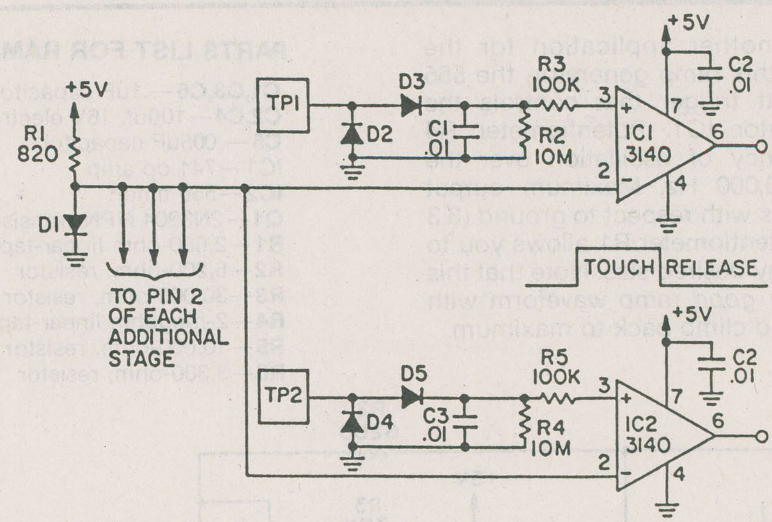
There's no better way to add an exotic touch to a piece of electronic equipment than by employing touch-sensitive switching. The set-up diagrammed here will enable you to employ one, two or however many touch-sensitive switches you need. Electronic musicians, for example, may wish to use 37 units in a 3-octave keyboard.

Each separate unit consists of a touch plate, a silicon-diode detector system, and a 3140 op amp that functions as a voltage comparator. Finger contact with a touch plate feeds 60-Hz power-line radiation from your body, which acts as an antenna, to the detector system. If the rectified AC exceeds 1.2 volts, the 3140's output swings high and remains there for as long as you touch the plate. All stages use the .6-volt drop across D1 as a reference voltage. NOTE: If you're running a battery-operated device in Dogpatch, this touch-switching arrangement may not work. Most homes, however, have sufficient 60-Hz radiation to trigger these sensitive switches.

PARTS LIST FOR TOUCH-SENSITIVE KEYBOARD

C1—C4-.01-uF capacitor
D1-D5—1N914 diode
IC1-IC2—3140 FET-input op amp
R1—820-ohm, resistor
R2,R4—10,000,000-ohm, resistor
R3,R5—100,000-ohm,resistor
TP1,TP2—touch plates (small, aluminum or copper)

TOUCH-SENSITIVE KEYBOARD



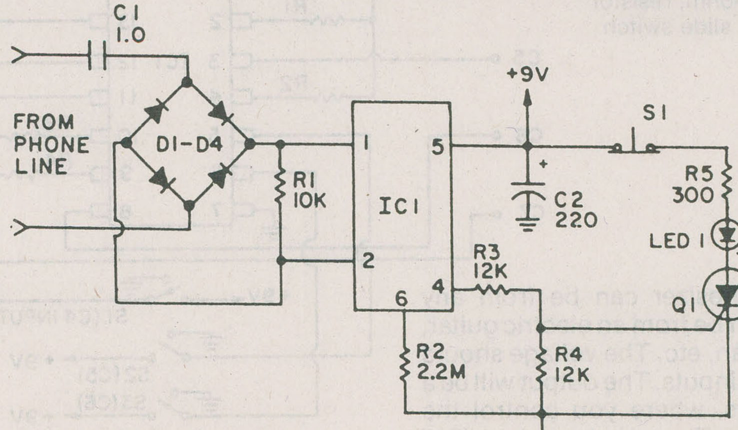
PHONE-CALL LOGGER

This inexpensive circuit is designed to let you know if a telephone call was received in your absence. Of course, it won't answer the phone or take a message, but when you consider that the necessary cash outlay is about 5% of the cost of a typical answering machine, this phone-call logger begings to look appealing.

Diodes D1 through D4 rectify the 20-Hz phone-ringing signal and feed it to the LED inside optocoupler IC1. Light from the LED actuates a phototransistor inside IC1. The phototransistor conducts and causes a pulse of current to flow to the gate of Q1, a silicon-controlled rectifier. Upon receiving the gate pulse, Q1 latches in a conducting state and lights up LED1. When you return home, you'll know that cousin Clem called. Pressing S1 extinguishes LED1 until the next call comes in. Please note that if you are hooked into a multi-party line, you will log not just your own calls, but those of everyone else on the line as well.

PARTS LIST FOR PHONE-CALL LOGGER

C1—1.0uF, 200V Capacitor
C2—220uF, 25V capacitor
D1 thru D4—1N4003 1A, 200PIV rectifier diode
IC1—MCT-2 optocoupler
LED1—light-emitting diode
Q1—2N5060 sensitive-gate SCR
R1—10,000-ohm, resistor
R2—2.2 Megohm, resistor
R3, R4—12,000-ohm, resistor
R5—300-ohm, resistor
S1—SPST normally closed pushbutton switch

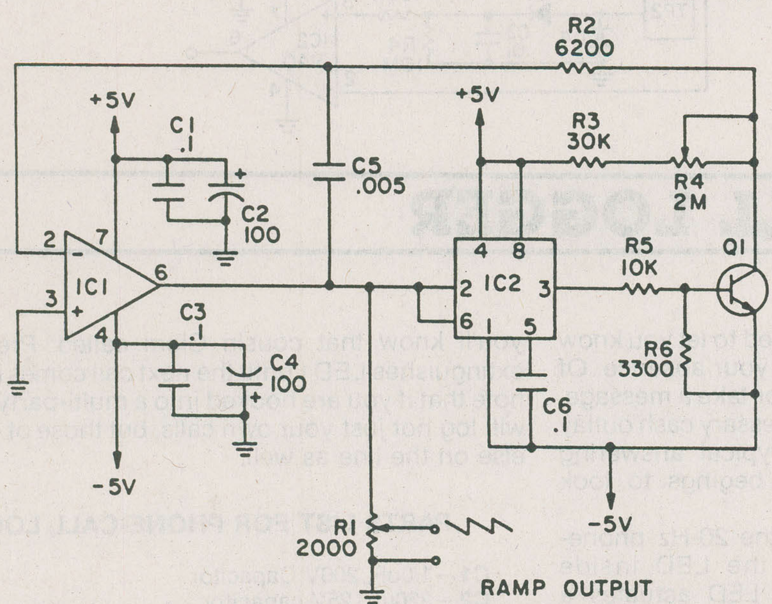


RAMP GENERATOR

We present here another application for the versatile 555 timer. In this ramp generator, the 555 functions as a Schmitt trigger that controls the current fed to integrator IC1. Potentiometer R4 determines the frequency of oscillation over the range from 150 to 10,000 Hz. Maximum output amplitude is ± 1.67 volts with respect to ground (3.3 volts peak-to-peak). Potentiometer R1 allows you to trim the amplitude to any desired size. Note that this circuit produces a *very good* ramp waveform with slow descent and a rapid climb back to maximum.

PARTS LIST FOR RAMP GENERATOR

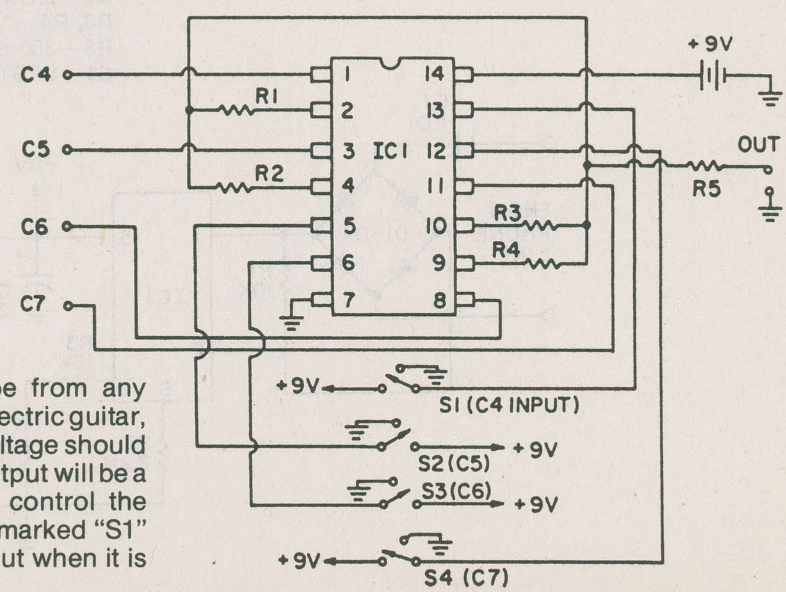
C1,C3,C6—.1uF capacitor
C2,C4—100uf, 16V electrolytic capacitor
C5—.005uF capacitor
IC1—741 op amp
IC2—555 timer
Q1—2N3904 NPN transistor
R1—2,000-ohm linear-taper potentiometer
R2—6,200-ohm, resistor
R3—30,000-ohm, resistor
R4—2-megohm linear-taper potentiometer
R5—10,000-ohm, resistor
R6—3,300-ohm, resistor



MULTI-INPUT MUSIC SYNTHESIZER

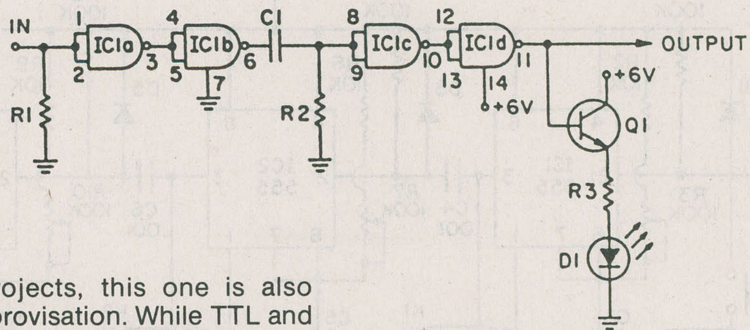
PARTS LIST FOR MULTI-INPUT MUSIC SYNTHESIZER

IC1—4016 quad bilateral switch
R1 through R5—1,000-ohm, resistor
S1 through S4—SPDT slide switch



The input to this synthesizer can be from any musical instrument. C4 can be from an electric guitar, C5 from an electronic organ, etc. The voltage should not exceed 9 volts at these inputs. The output will be a combination of the inputs, where you control the combining via the switches. The switch marked "S1" will put the C4 input through to the output when it is switched to the down position.

IMPROVISED MONOSTABLE



Like the preceding projects, this one is also dedicated to the art of improvisation. While TTL and CMOS prepackaged monostable multivibrators are available, one may not be at hand when such a useful device is called for. Once again, two very common gates, the 4001 quad NOR and the 4011 quad NAND will equally fill the bill. In operation, when the input is made high, the output of the first inverter goes low, forcing the output of the second high, charging the capacitor C1 through resistor R2. For a while, the output of the third gate is driven low, causing the output stage to go high, activating the LED indicator. In this elementary circuit, it is only necessary that the turn-on signal remain high for at least the duration of the timed interval.

PARTS LIST FOR IMPROVISED MONOSTABLE

C1—0.1-uF ceramic capacitor, 15VDC
D1—small LED
IC1—4001A or 4011A quad NAND gate
Q1—2N4401
R1, R2—47,000-ohm, ½-watt resistor
R3—470-ohm, ½-watt resistor

SEQUENTIAL TIMER

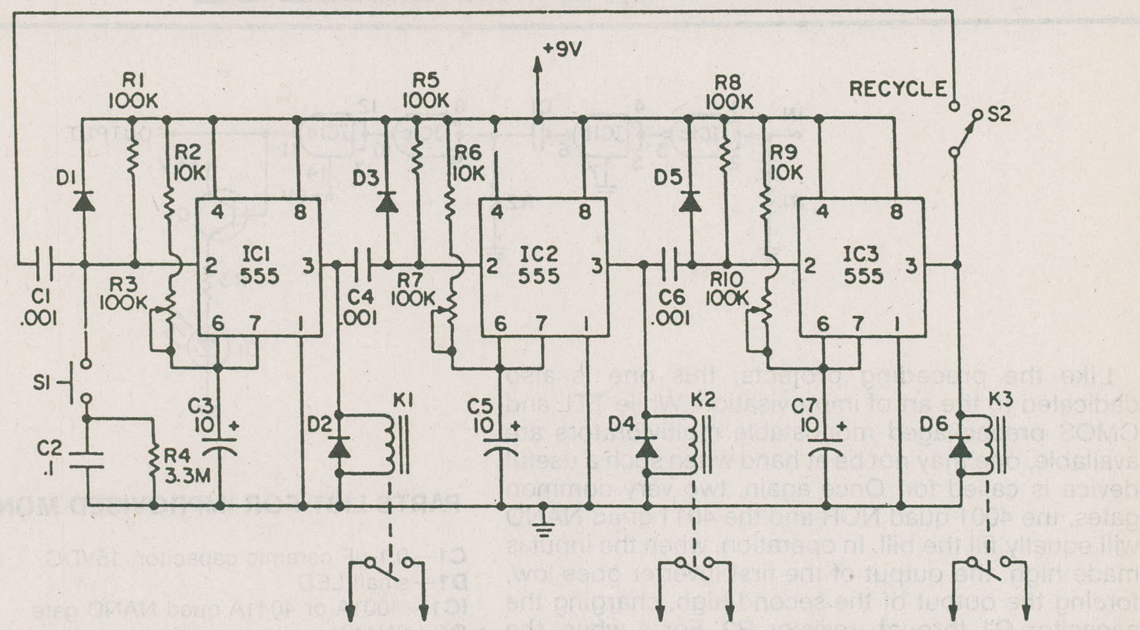
Press S1, and relay K1 pulls in for a time interval determined by the setting of R3. When IC1 times out and K1 opens once again, IC2 gets triggered. This causes K2 to pull in for an interval determined by R7's setting. Finally IC2 will time out and trigger IC3, thereby causing K3 now to pull in. Once IC3 times out and K3's contacts open, action ceases if S2 is flipped to the right. However, if S2 had been flipped to the left, IC1 would have once again been triggered as IC3 timed out, thus starting the whole cycle over again.

With the values shown, each timer can be adjusted for times from .1 to 1 second. If your application demands longer timing intervals, simply increase the size of the timing capacitors (C3, C5 and C7) and/or the timing resistors (R2-R3, R6-R7, and R9-R10). One application of the circuit that comes to mind is in flash photography. Let each relay fire a separate, cheap flash unit. With the timers adjusted for rapid fire, you'll be able to take stroboscope-like pictures that you couldn't take with a single conventional flash unit because re-cycle times (.3-.5 seconds) are too long. With three units each flash has ample time to re-cycle while the others are firing. You might also try using color film and putting a separate colored filter over each flash tube.

PARTS LIST FOR RE-CYCLING SEQUENTIAL TIMER

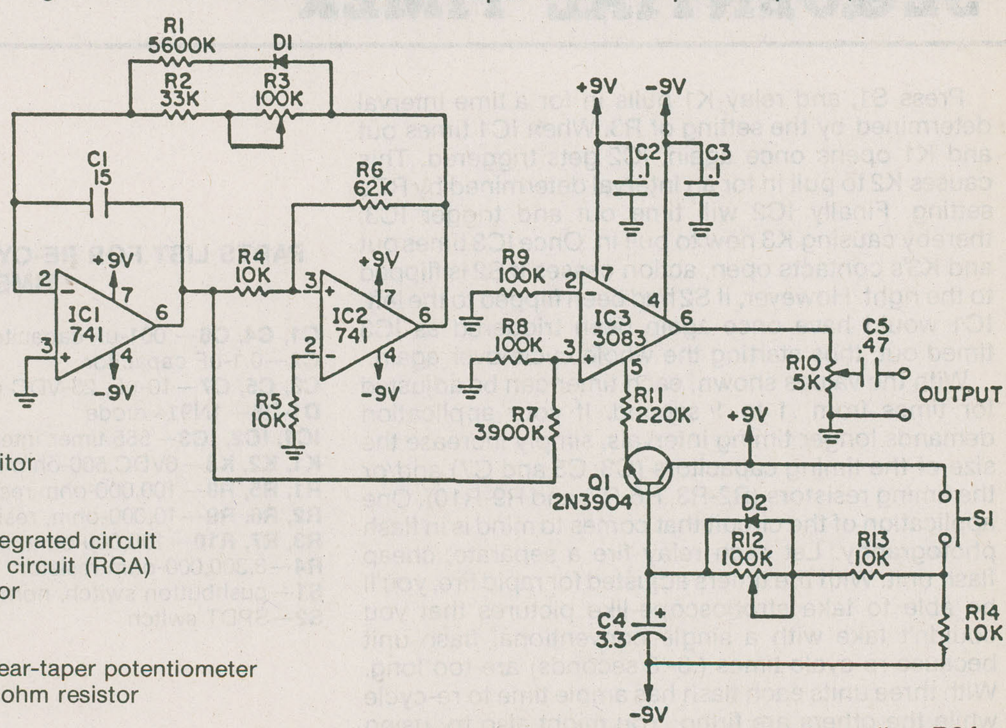
C1, C4, C6—.001-uF capacitor
C2—0.1-uF capacitor
C3, C5, C7—10-uF, 25-VDC capacitor
D1-D6—1N914 diode
IC1, IC2, IC3—555 timer integrated circuit
K1, K2, K3—6VDC,500-ohm relay
R1, R5, R8—100,000-ohm,resistor
R2, R6, R9—10,000-ohm, resistor
R3, R7, R10—100,000-ohm, linear-taper potentiometer
R4—3,300,000-ohm resistor
S1—pushbutton switch, normally open
S2—SPDT switch

SEQUENTIAL TIMER



SLIDE TROMBONE

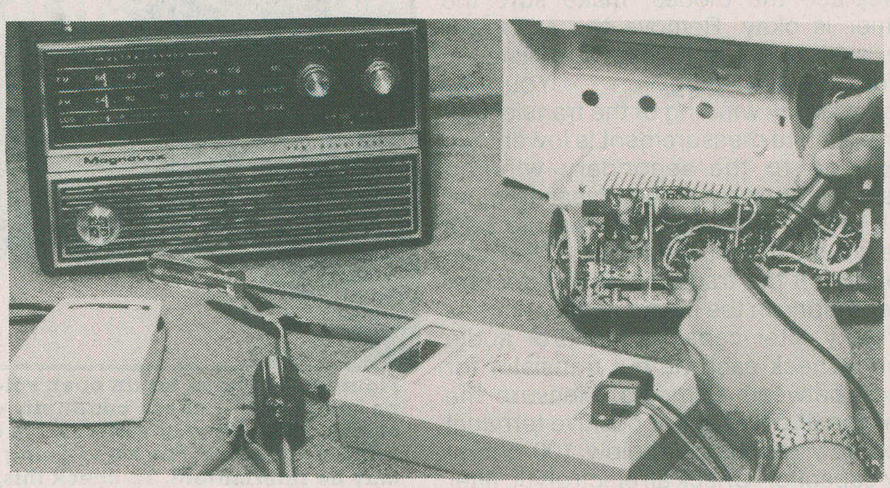
This is a novel little instrument that can be played through your stereo system. IC1 and IC2 comprise a ramp generator, the frequency of which is adjusted by R3. The range of adjustments spans two octaves from 150 to 600 Hz. The ramp signal is fed to modulator IC3, which imparts a natural-sounding attack and decay to the note that sounds when S1 is pressed. R12 allows adjustment of the note's decay interval, and R10 controls the volume. Maximum signal amplitude at the output is 500 mV peak to-peak (sufficient to drive an amp's high-level input). To play, adjust R3 for a particular note; press S1; slide R3; then release S1. You can make things easy by calibrating R3 in terms of musical notes. Either a slide or rotating pot can be used for R3, depending on your playing preferences.



PARTS LIST FOR SLIDE TROMBONE

C1—0.15-uF capacitor
C2, C3—0.1-uF capacitor
C4—3.3-uF, 25VDC capacitor
C5—0.47-uF capacitor
D1, D2—1N914 diode
IC1, IC2,—741 op amp integrated circuit
IC3—3080 amp integrated circuit (RCA)
Q1—2N3904 NPN transistor
R1—5,600-ohm resistor
R2—33,000-ohm resistor
R3, R12—100,000-ohm linear-taper potentiometer
R4, R5, R13, R14—10,000-ohm resistor
R6—62,000-ohm resistor
R7—3,9000-ohm resistor
R8, R9—100-ohm resistor
R10—5,000-ohm audio-taper potentiometer
R11—220,000-ohm resistor
S1—pushbutton switch, normally open

10 EASY WAYS TO FIX



PORTABLE RADIOS

By Homer L. Davidson

Because most portable radios are rather inexpensive to begin with, most radio-TV repair shops won't tackle them today. But you don't have to toss that non-working set in the trash can. Most of the time you can get it back in good operating condition yourself, just by following these ten easy repair tips.

What You Need

You'll need a meter to make these ten common repairs on most portable radios. You should have either a voltohmmeter (VOM), or the more modern DMM, a digital multimeter. Using one of these meters you'll be able to find leaky or open diodes and power supply rectifiers, bad transistors, or open speakers and transformer windings.

Before you do anything else, visually inspect the radio with the case removed. A broken dial cord or a snapped antenna is easy to spot, but lots of other problems can also be located, if you look carefully.

Bad Sound

If the sound is raspy or scratchy, it may be due to a speaker with a hole or tear in its paper cone. Or the cone may be loose. You may have to remove the speaker to check this by removing the two or four screws holding it to the case. Dirty volume controls can also be detected by sound. The rest of the ten most common problems can be found using the VOM or DMM.

Burned Diodes

Most radio problems are found in the audio output on the power supply circuits. Check the batteries and terminals if the radio is dead in battery operation. If the radio is dead in the ac operation, inspect the on/off switch and the silicon rectifiers. A burned diode can be seen easily (Fig.1). Remove one end of each diode and take an accurate resistance measurement, if no burn marks can seen.

A leaky diode will have a low resistance measurement in both directions. Replace the diode if you find low resistance (below 350 ohms). Now reverse the test leads and take another measurement. Install a new silicon diode if you have a low reading. A normal diode should show low ohms measurement in one direction, and infinite measurement with reversed test leads.

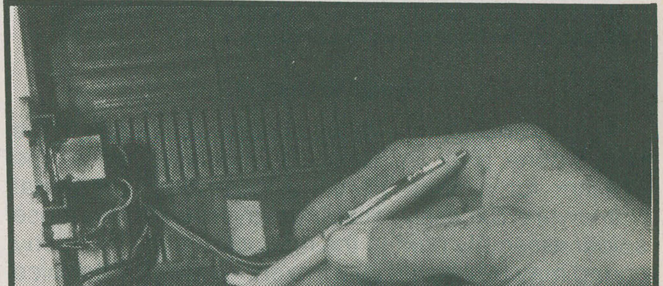


Figure 1. If there's no sound (and the speaker is OK) a good bet is burned or leaky silicon rectifier diodes in the power supply. Check with a flashlight if necessary. Replace with a one amp, two, or 2.5 amp rectifier.

A leaky or burned diode may have become defective from internal leakage, lightning damage or overloaded circuits. Usually, if lightning damage is found, you would just toss the radio out. Before attempting to replace the diodes, make sure the power transformer is okay. Remove the ac power plug. Turn the switch on and take a resistance measurement across the ac plug. You may safely assume the primary winding of the transformer is normal if the resistance measurement is lower than 500 ohms. Next, go to the secondary winding terminals and take another resistance measurement to determine if it is OK. The secondary should be a few hundred to a couple of thousand ohms. The radio is not worth repairing if the transformer is defective.

Overloaded conditions in the power supply circuits are caused by leaky filter capacitors and/or audio output transistors. Check each output transistor for shorts or leakage between elements. Measure the resistance across the filter capacitor positive terminal and ground. Real low resistance (below 100 ohms) indicates a leaky capacitor. Check all electrolytic filter capacitors in the same manner.

Figure 2. Check the speaker for holes, tears, or a frozen or rubbing voice coil. To check for frozen or rubbing coil, gently move the coil with a thumb or finger on each side of the middle.

Noisy Speakers

A noisy speaker may have holes or torn areas in the paper cone (Fig. 2). Check the outside rim of the speaker for a cone vibrating loose from the metal framework. Excessive blatting may result from a loose spider assembly next to the magnet. A tinny or mushy sound may be caused by a frozen voice coil. The voice coil assembly is directly against the magnet pole area. Use another speaker of any size to determine if the speaker is defective.

A dead speaker may be caused by an open voice coil. Rotate the function switch of your meter to the lowest ohm range. Remove one speaker lead and take a continuity resistance measurement. No resistance indicates the voice coil is open. When a VOM is used to check the voice coil, the resistance will be 1 or 2 ohms (Fig. 3). Replace the defective speaker with the correct ohms impedance, size and shape.

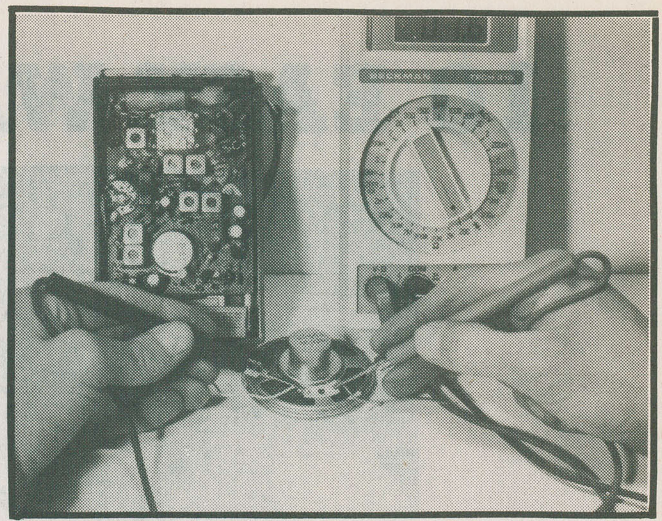
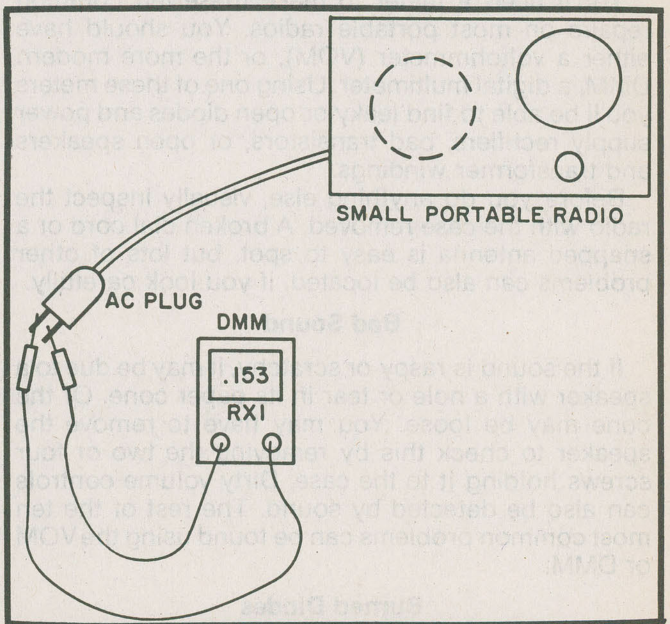


Figure 3. To check for an open voice coil (if there's no sound at all) check continuity on the lowest ohms scale with your meter. If it's open you'll get infinity of course. The wires going to the voice coil may be intermittent. To check this, move the cone back and forth (as described in Figure 2) while the meter is connected to the voice coil terminals.

No Sound

No hum and no click in the speaker may indicate an open on/off switch or dead batteries. Suspect the batteries or terminals if the radio operates on ac but not on dc. Check the power supply when the radio operates on batteries but not on ac. If the radio is dead on both ac and dc power, suspect a defective output transistor.

Measure the dc voltage at the on/off switch terminals. Now check the dc voltage at the collector terminals of the output transistors. No voltage at the collector terminal may indicate a broken wire or bad switch. Very low voltage may indicate a leaky output transistor. Replace output transistors if they are real hot, with no audio output.



The power transformer of the portable radio may be quickly checked with a resistance measurement across the AC power cord. Remove the power plug from the wall for resistance measurements.

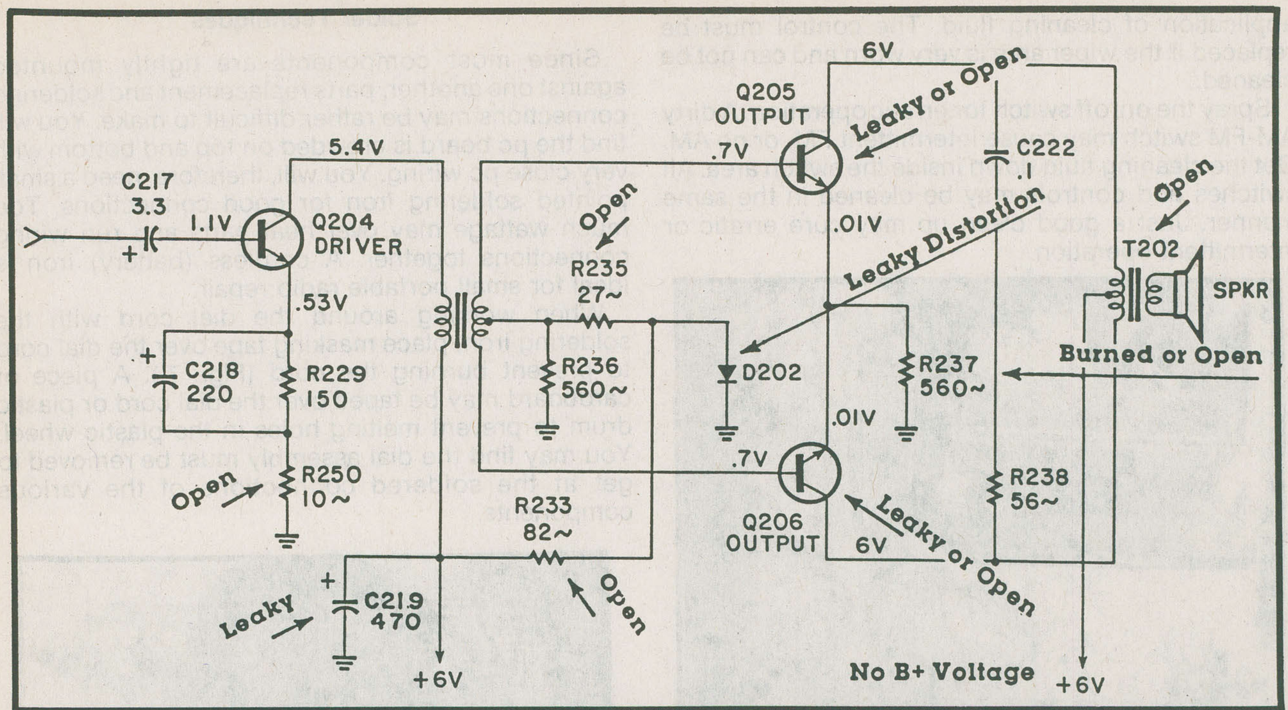


Figure 5. Here's another schematic (of a different radio). The arrows show various places to check. The schematic shows points you can inspect with your meter for dead or intermittent operation.

In large ac-dc battery operated portable radios you may find one IC output component. Check the speaker by clipping another pm speaker across the speaker terminals. Sometimes the earphone jack contacts are dirty or open, preventing speaker operation. Clip the test speaker ahead of the earphone jack terminals to see if the jack is defective.

Take accurate voltage measurements at the IC terminals. Real low voltage at the supply terminal may indicate a leaky IC or improper applied voltage (Fig. 4). In this Sanyo M2560 portable radio, all voltages were fairly normal at IC 101, but no sound. The cause? C116 (470UF) was open between IC terminal 1 and the speaker.

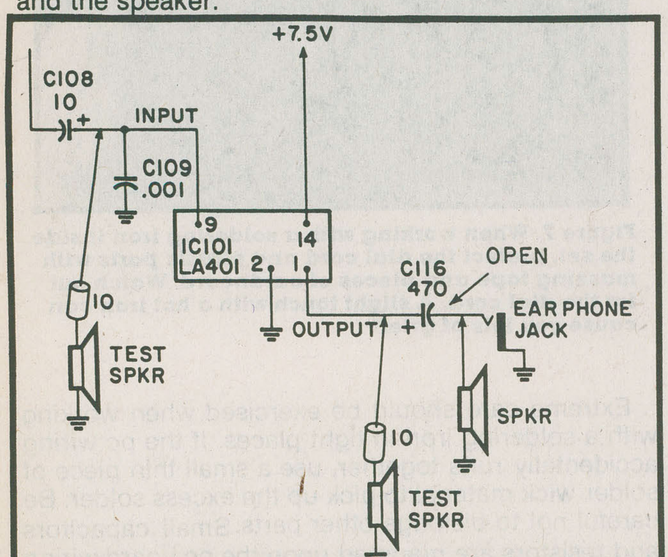


Fig. 4. Here's the schematic of a typical audio section. Use a separate speaker with an electrolytic capacitor as a signal tracer. You can also check with the second speaker at the earphone jack.

You can signal trace the audio signal after the first AF or driver transistor with an electrolytic capacitor and a small speaker. Add a couple of flexible leads to the speaker and insert the capacitor between one lead and the probe. Touch the test probe to the collector or coupling capacitor lead of the AF or driver transistor. The sound maybe weak here, but if the front end is normal, you will hear music by placing your ear next to the speaker. Go to the base terminal of the output transistor or IC component. If the signal is normal at the input, and there's none at the output, suspect a leaky or open transistor or IC.

The audio output transistor may be checked in the circuit for leakage and open test with the DMM. Set the function switch to diode test, and check leakage between all terminals. The transistor may be checked for an opening between the base and the collector or between the base and emitter terminals (Fig. 5). Remove the transistor from the circuit if the tests are erratic or you are not convinced the transistor is okay.

A quick way to remove and install a small output transistor with wire leads is to cut off the leads close to the body of the transistor. Since the leads are difficult to get at on a crowded pc board, this is the best and quickest method for replacement. Leave an inch or so of the lead soldered to the pc board to hook on to. Form a half circle out of the remaining terminal lead. Write down where the collector, base and emitter terminals are on a scrap of paper so you can install the new one. Push the correct terminal lead through each half circle and solder each. Double check each lead.

Erratic Controls

A noisy or erratic volume control may be repaired by spraying cleaning fluid down inside the control area. Point the spray tube inside the contact control terminals. Rotate the volume control between each

application of cleaning fluid. The control must be replaced if the wiper area is very worn and can not be cleaned.

Spray the on/off switch for erratic operation. A dirty AM-FM switch may cause intermittent FM, or no AM. Get the cleaning fluid down inside the switch area. All switches and controls may be cleaned in the same manner. Just a good clean up may cure erratic or intermittent operation.

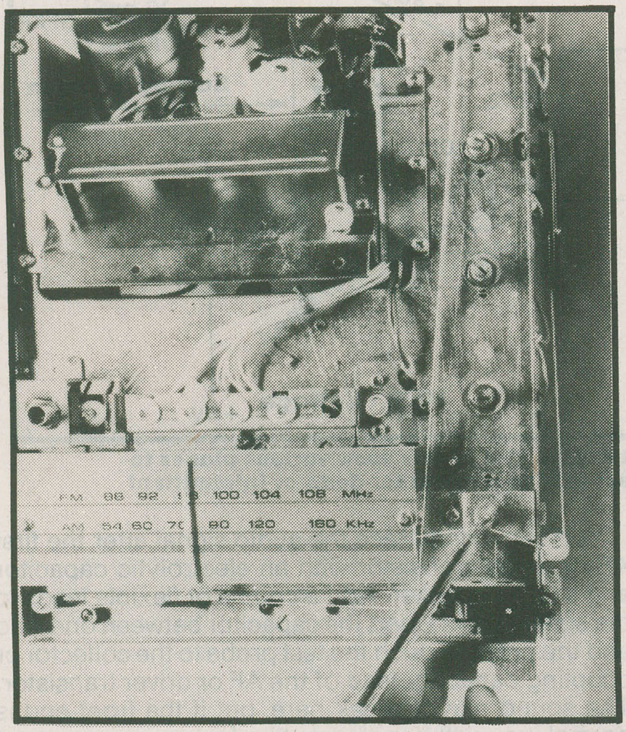


Figure 6. Tuning indicator slippages usually happen when the dial cord is slipping at the dial cord drive shaft. Put a little liquid rosin on the shaft.

Dial Cord Repair

The dial pointer may move slowly across the dial or just stay in one place, indicating dial slippage. No movement at all may be caused by a broken dial cord. Often, one end of the dial cord will break out of the plastic hole in the drum area allowing the cord to become loose. Slippage usually occurs at the dial turning shaft (Fig. 6).

Inspect the dial cord for breakage or worn spots. If the dial cord has just stretched or become larger, remove spring and cut off a couple of turns with wire cutters. Another method is to remove the spring end and tie a couple of knots in the cord, close to the spring. This will tighten a loose cord. Alternatively, you can tie another small dial spring at the other end of the cord. Now you have a spring at each end to keep the cord tight.

Draw a rough sketch of the dial cord stringing if the cord has broken. Leave the string exactly where you find it and try to figure out where it was before it broke. Notice how many turns are around the dial shaft. Determine which direction the cord travels so the cord is not wound on backwards. In most cases, the dial pointer travels in the same direction as the dial knob is rotated.

Solder Techniques

Since most components are tightly mounted against one another, parts replacement and soldering connections may be rather difficult to make. You will find the pc board is crowded on top and bottom with very close pc wiring. You will, therefore, need a small pointed soldering iron for good connections. Too much wattage may over heat parts and run wiring connections together. A cordless (battery) iron is ideal for small portable radio repair.

When working around the dial cord with the soldering iron, place masking tape over the dial cord to prevent burning the cord (Fig. 7). A piece of cardboard may be taped over the dial cord or plastic drum to prevent melting holes in the plastic wheel. You may find the dial assembly must be removed to get at the soldered connections of the various components.

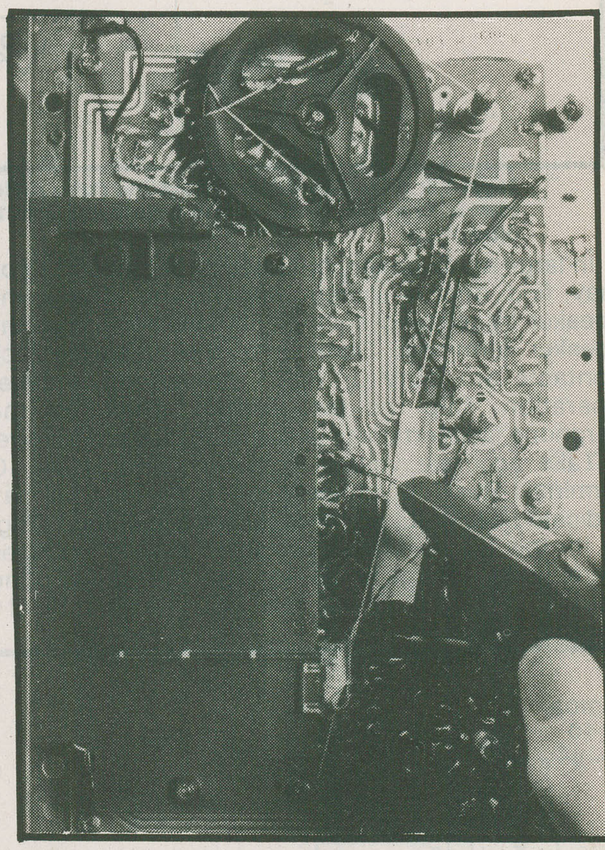


Figure 7. When working with a soldering iron inside the set, protect the dial cord and plastic parts with masking tape and pieces of cardboard. Watch out for the dial cord. A slight touch with a hot iron can cause you lots of grief!

Extreme care should be exercised when working with a soldering iron in tight places. If the pc wiring accidentally runs together, use a small thin piece of solder wick material to pick up the excess solder. Be careful not to dislodge other parts. Small capacitors and resistors are mounted upon the pc board wiring area and drop off while soldering nearby. Take the blade of a pocket knife and clean out between wiring and terminals.

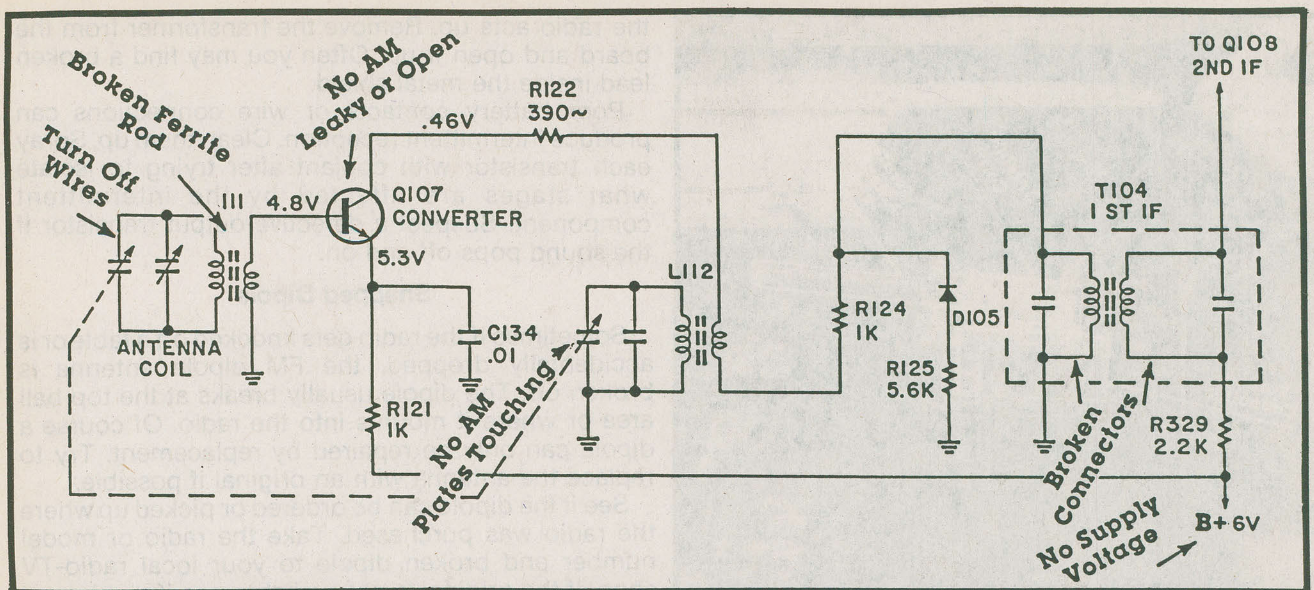


Figure 9. Most small portables have one transistor serving as both the RF amplifier and the local oscillator. If you have no AM reception, test this transistor.

Weak AM

Suspect a broken ferrite antenna rod or defective RF transistor when only local stations can be heard (Fig. 8). Carefully inspect the antenna coil for a broken black rod. The ferrite rod may break inside the coil if the radio is dropped. The antenna coil may be repaired by installing a new rod. Replace the whole antenna coil assembly if a rod replacement is not avaiable.

Check the antenna coil for broken leads. The fine wiring found on most antenna coils must be tinned before a good connection is made. Scrape off the insulation with the blade of a pocket knife. Apply rosin core paste to the wire. Heat the piece of wire with the soldering iron while applying solder. Now the broken wire may be replaced with a good soldered connection.

A leaky or open RF transistor may cause weak AM reception. You will not find an RF transistor in smaller portable radios. A converter transistor serves both as RF and oscillator transistors (Fig. 9). An RF transistor will be found near the three-ganged tuning capacitor, in large multiband receivers. Separate RF, oscillator and mixer transistors will be found in these radio circuits.

No AM, No FM

Clean the AM-FM switch for poor contacts when no AM or FM can be tuned in. Check the low voltage source feeding both circuits. With low (or no) supply voltage, check for a leaky zener diode or decoupling filter capacitor. Usually, the FM circuits have RF and converter transistors while the AM circuit may consist of one converter transistor (Fig. 10).

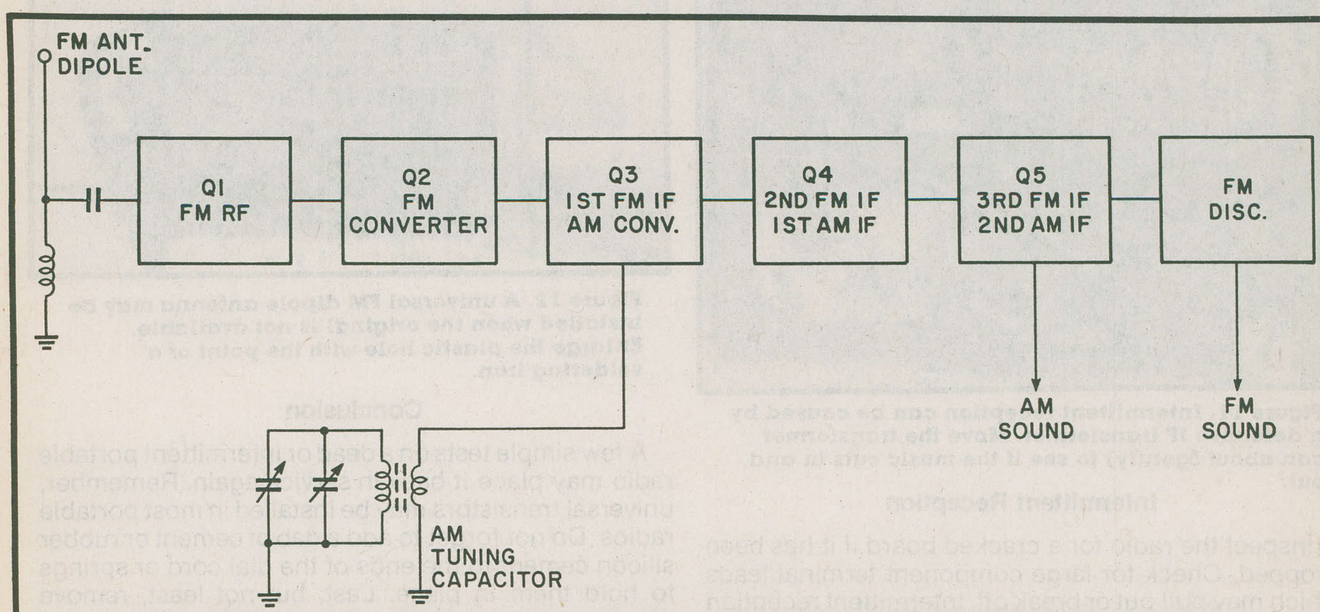


Figure 10. Here's a block diagram of a typical radio. This shows how the AM and FM sections tie together near the front end.

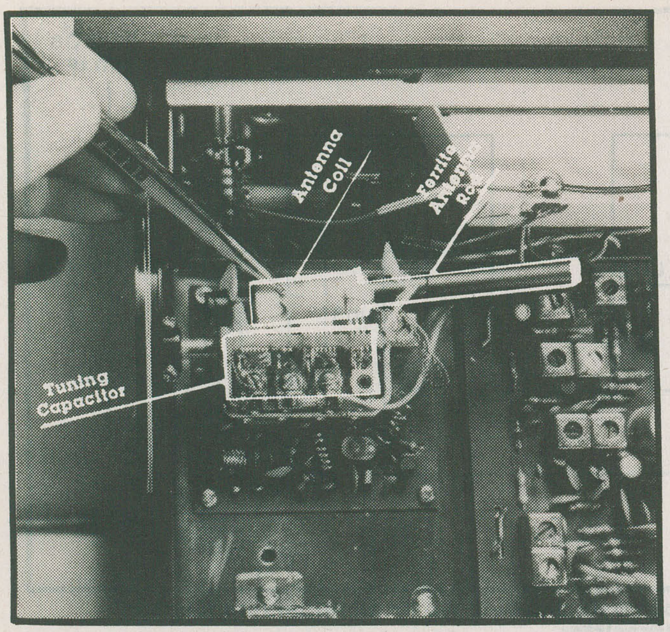


Figure 8. If there's weak AM reception a common cause is a broken wire at the ferrite rod antenna. Check it for broken wires leading to the circuit. One wire should go directly to the tuning capacitor (the part with the most plates).

No AM or FM reception may be caused by a defective IF stage. Sometimes the first IF stage serves as both the AM convertor and FM IF stage. To determine if the AM convertor is working, place the portable radio near another radio and tune the entire band. If the AM oscillator stage is functioning, you will hear a squeal in the other radio as you cross the band indicating the AM convertor stage is normal. Then check each transistor in the IF stages. Isolate the defective transistor with in-circuit voltage measurements.

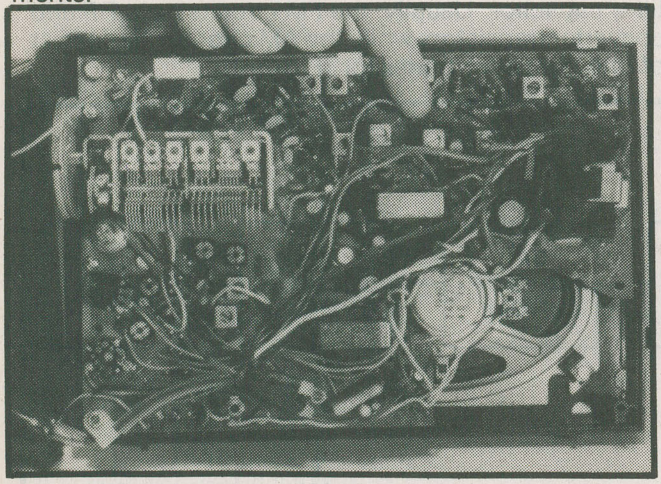


Figure 11. Intermittent reception can be caused by a defective IF transformer. Move the transformer can about (gently) to see if the music cuts in and out.

Intermittent Reception

Inspect the radio for a cracked board if it has been dropped. Check for large component terminal leads which may pull out or break off. Intermittent reception may be caused by poor IF transformer connections (Fig. 11). Move the transformer around and notice if the radio acts up. Remove the transformer from the board and open it up. Often you may find a broken lead inside the metal shield.

Poor battery contacts or wire connections can produce intermittent reception. Clean them up. Spray each transistor with coolant after trying to isolate what stages are affected by the intermittent component. Suspect a defective output transistor if the sound pops off and on.

Snapped Dipole

Sometimes if the radio gets knocked off a table or is accidentally dropped, the FM dipole antenna is broken off. The dipole usually breaks at the top ball area or where it mounts into the radio. Of course a dipole can only be repaired by replacement. Try to replace the antenna with an original if possible.

See if the dipole can be ordered or picked up where the radio was purchased. Take the radio or model number and broken dipole to your local radio-TV shop. If the original is not available, see if a universal type will mount into the plastic case (Fig12). You may be able to pick up universal dipole antennas at Radio Shack or at a local electronic supply house.

The universal replacement can be mounted on any plastic case provided there is room inside the radio. A larger hole may be drilled to accomodate the new antenna mount. The hole may be enlarged with the tip of a soldering iron. Be careful not to make the hole too large. Metal washers may be used on top and bottom if the original hole is too big for the universal replacement.

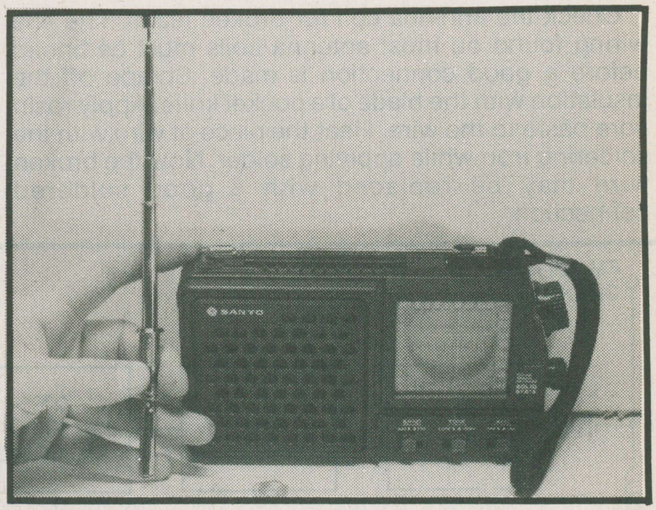


Figure 12. A universal FM dipole antenna may be installed when the original is not available. Enlarge the plastic hole with the point of a soldering iron.

Conclusion

A few simple tests on a dead or intermittent portable radio may place it back in service again. Remember, universal transistors may be installed in most portable radios. Do not forget to add a dab of cement or rubber silicon cement to the ends of the dial cord or springs to hold them in place. Last, but not least, remove those old batteries from the radio if it stays on the shelf or remains unused too long. This will prevent battery leakage over the other components. ■

THE CATALOG CORNER

If you live in a relatively remote area that doesn't have ready sources for electronic parts, you can send away to numerous supply houses, who have good catalogs of electronic parts and assemblies...many of them real bargains.

Following are several catalogs that we have recently received in the mail, with brief descriptions and comments. Most of these suppliers send out new catalogs every four to six months, with many of the items repeated and new ones added, plus some new "specials"...usually on the first couple pages and the last few pages of each issue.

HEATHKITS

You probably already know about The Heath Company, of Benton Harbor, Michigan. But you may not have known until now, that Edward Heath made and sold a kit airplane before the Second World War, and right after World War II, he got into making electronic kits. The first one was a 3½-inch oscilloscope using mostly WWII surplus military parts.

Heath makes more kits than everyone else combined, and now their 108-page catalog (free on request of course) lists hundreds of kits, and lots of already-assembled units. You can get ham radio sets from the simplest beginner's transmitters and receivers to the most elaborate and expensive ones you can imagine. You can build instruments for car tuneup, computers (expensive but good), fishing and boating instruments, a robot (Hero he's called), TV sets (expensive, but the best), satellite systems and components, oscilloscopes and lots of other test instruments.

The Heath catalog is worth getting just to read for fun, even if you're not ready to buy anything from them today. You can order from them via their toll-free telephone line (1-800-253-0579) and use your credit card. They also have a telephone line for immediate help if you have any trouble assembling any of their kits.

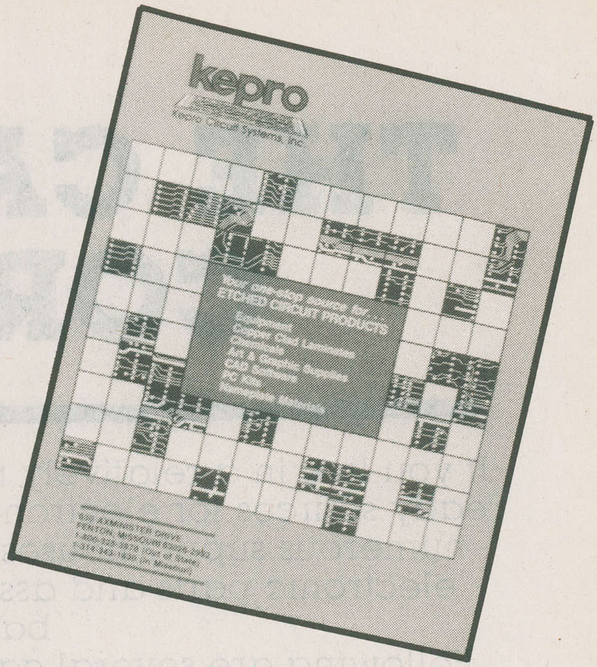
Their kit plans are as nearly perfect as humanly possible. I've put together more than 10 of their kits in the past 20 years, with almost no problems of any sort. Those few problems that did come up were my own fault, and in every case they were quickly straigtened out using their telephone Help line.

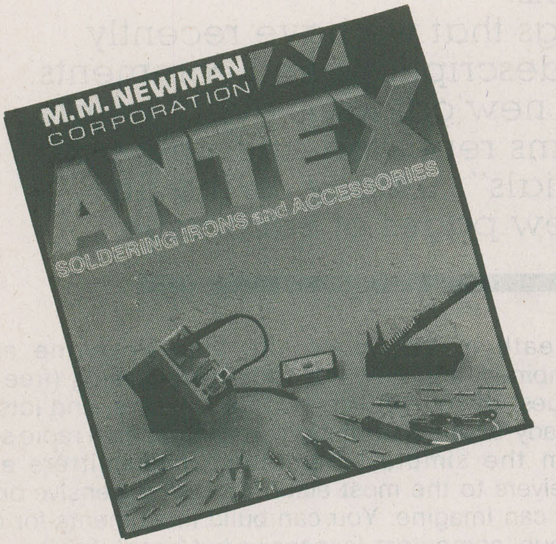
Whether you plan to get into kit building now or later, you should definitely have the current Heath catalog in your shop at all times. You can drop Heath a postcard at **Box 1288, Benton Harbor, MI 49022,** or phone 'em at **616—982—1313.**

KEPRO CIRCUIT BOARD KITS

Kepro has specialized for many years in supplying chemicals and machines for companies that make large quantities of printed circuit boards. They call 'em, correctly, Etched Circuit Boards. This 32-page catalog shows (mostly) those supplies and machines for factories. But it includes four kits for individuals. They're three at $9.95 to $12.95, each of which yields several professionally-fabricated boards, and one Artwork Master Photo layout kit for somewhat more advanced builders. That one costs about $90.

If you're into PC (printed circuit) boards, or would like to enter this important area of electronic construction, this is the perfect way to do it. Get this free catalog (address below) and study it, briefly. Then order one of their kits—and enter the world of professionally-fabricated-by-you PC boards. Write to **Kepro Circuit Systems, Inc. at 630 Axminster Drive, Fenton, MO 63026.**





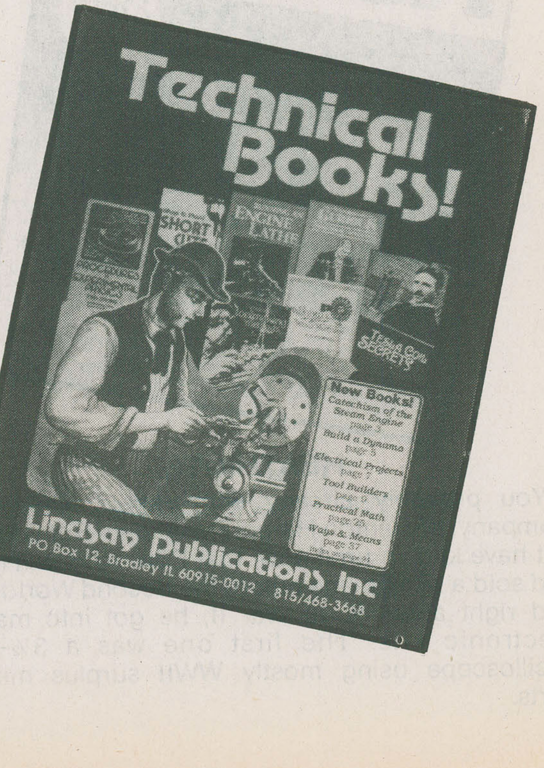
SOLDERING IRON CATALOG

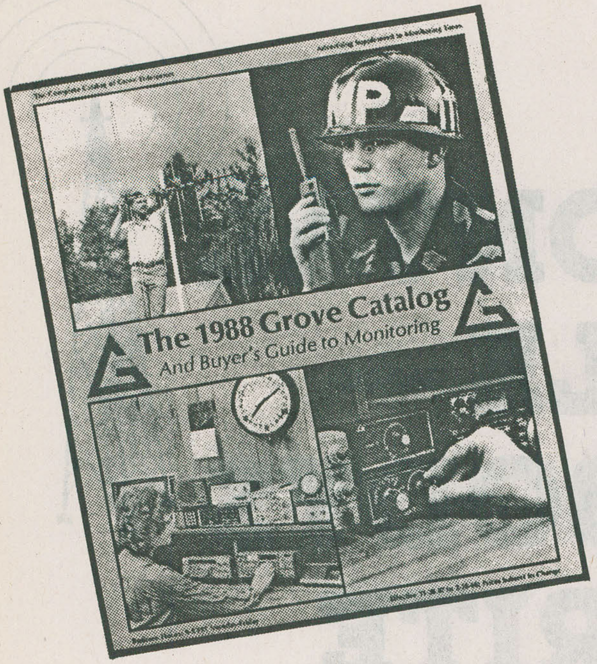
M.N. Newman makes dozens of different soldering irons and soldering pencils. Most of them are miniature units and they have a very wide variety of irons and replacement tips. Newman also markets temperature-controlled soldering-iron stations with precision temperature control. To get their catalog, write **M.N. Newman, 24 Tioga Way, Box 615, Marblehead, MA 01945.**

LINDSAY'S TECHNICAL BOOKS

96 pages of books, one or two to a page, lots of them on electrical subjects, but covering plenty of mechanical, optical, and too many other subjects to mention. A sampling includes such topics as metalworking, steam engines, building machine tools, making bricks, making electric welders, melting metals, electroplating, building lathes, and many other subjects. Most of the books cost between $3.50 and $10.00, though some list for less, and a few for more.

It appears that most of these books are reprints, and as a result cost much less than they would if they were newly published. The ones I've seen were excellent values. *Everyone* should have Lindsay's catalog. Send a postcard to **Lindsay Publications, Inc., Box 12, Bradley IL, 60915, or telephone 815—468—3668.**





GROVE'S CATALOG

BUYER'S GUIDE TO SHORTWAVE LISTENING

Choosing a shortwave receiver or a shortwave scanner is much like choosing a car—first you have to decide what basic functions you need; then you select the right product. Grove's Guide is a crash course in choosing your shortwave receiver or scanner, the antenna, and the accessories such as transmission line, RF preamplifiers, filters and attenuators, active antennas, tuners and preselectors.

This 32-page catalog is jam-packed with information far beyond the details of the equipment. For example, it lists the Top 100 Shortwave Listening Frequencies. A few of these are Mississippi River barges, many ship-calling channels, Canadian Air Force, US Air Force air/ground, RAF flight weather, and NOAA hurricane hunters. Also listed are the top 100 Scanner Frequencies (medical paging, Mc Donald's order window, Army Search/Rescue, Russian Cosmonauts, satellites, space schuttle, etc.

The equipment offered ranges from Grove's own Minituner ($49.00) up through the "Ultimate Receiver," the JRC NRD-525 which goes for $1169.00. In between there are a dozen more units, all pictured and described fully. Grove's no-questions-asked money-back guarantee policy runs for 15 days. You pay only the shipping costs. **Grove Enterprises, Box 98, Dog Branch Road, Brasstown, NC 28902, or telephone 704-837-9200.**

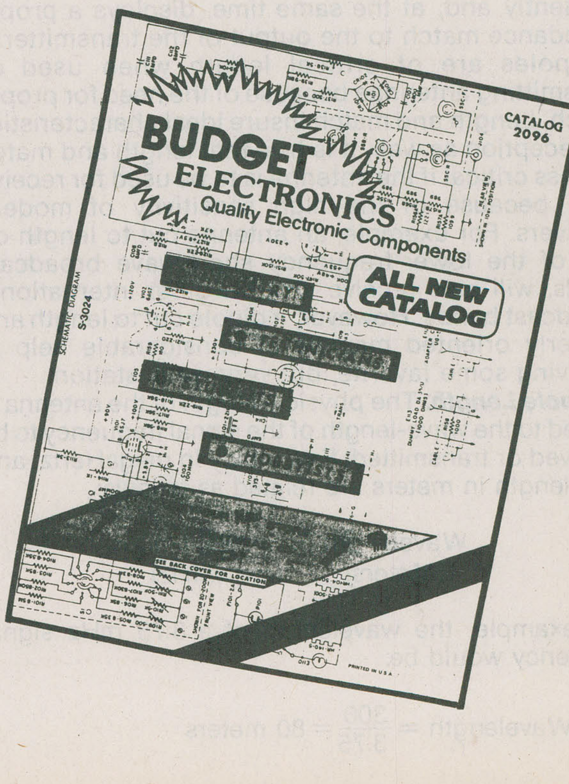
BUDGET ELECTRONICS

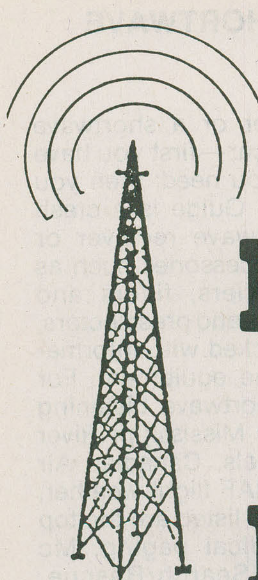
As the name implies, BUDGET ELECTRONICS has an impressive list of quality components, kits, books and other goodies at budget prices. They offer lots of components: passive as well as active, including transformers, project kits, enclosures, LED's, connectors, transistors and a wide assortment of TAB books. All are a must for hobbyists and technicians.

For beginners in the electronics hobby and the bargain hunters, we suggest they check the front end of the BUDGET ELECTRONICS catalog (available on request) for "Electronics Parts Assortments". These "Budget Assortments" (up to 115 pieces of hand selected, every day, usable parts, including capacitors, resistors, LM324, 7812 TO-220, T1 3/4 Red LEDs, 1N4148, 2N3904 and more, should let the beginning electronics hobbyist jump into the electronics hobby with both feet.

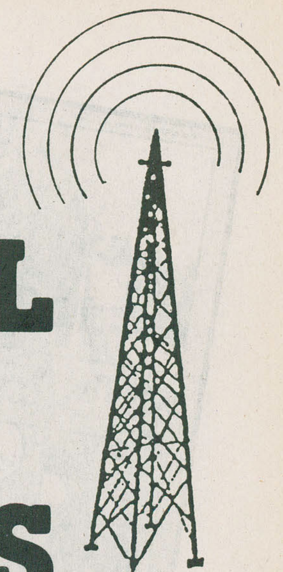
The supplier (BUDGET ELECTRONICS) emphasizes their customer service, with neatly organized, carefully packaged shipments and satisfied customers. Their mailing list customers receive frequent fliers with available current specials.

There is a $2.00 (Postage & Handling) fee for their catalog but it is worth it and it puts you on their mailing list for the flier specials. **BUDGET ELECTRONICS, P.O. Box #1477, Moreno Valley, CA 92337.**





HORIZONTAL DIPOLE— EVERYBODYS FAVORITE



THE HORIZONTAL DIPOLE is a simple effective antenna. Antenna wire and accessories required for construction are inexpensive and readily available. In fact make do replacements from surplus sources cost even less, or may be available for free.

It is the length of the dipole antenna that makes for efficient use as a receptor of an incoming radio wave. When used as a transmitting antenna, it radiates efficiently and, at the same time, displays a proper impedance match to the output of the transmitter.

Dipoles are of critical length when used as transmitting antennae because of the need for proper match. Length and match insure ideal characteristics for reception as well. It is true that length and match are less critical if the antenna is to be used for receive only, because of the high sensitivity of modern receivers. For example, an antenna cut to length on one of the lower-frequency short-wave broadcast bands, will also receive well on other international broadcast bands. However, a dipole cut to length and properly oriented may be of considerable help in receiving some favorite, but very weak station.

Dipole Length. The physical length of the antenna is related to the wave-length of the signal frequency to be received or transmitted. Frequency in megaHertz, and wavelength in meters are related as follows:

$$\text{Wavelength (Meters)} = \frac{300}{\text{freq. (MHz)}}$$

For example, the wavelength of a 3.75 mHz signal frequency would be:

$$\text{Wavelength} = \frac{300}{3.75} = 80 \text{ meters}$$

A dipole is a half-wavelength antenna and, therefore, its theoretical length would be one-half of this value, or 40-meters long. In practice, however, there are capacitive end-effects which cause a dipole that is cut to exactly the so-called "free-space" wave-length to be resonant on a lower frequency than the calculated value. In fact, to make the antenna an exact "electrical" half-wavelength long, it is necessary to shorten the physical length by 5-percent. Hence the dipole length for 3.75 MHz resonance would be:

$$\text{Dipole Half-Wavelength} = 0.95 \times 40 = 38 \text{ meters}$$

Since the dipole antenna is fed at the center and separated into two quarter-wavelength segments as shown in Fig. 1, each side of the antenna would be 19 ($38 \div 2$) meters long.

Physical antenna length for each quarter-wave segment of the dipole can be obtained by multiplying the 19 meters times the meters-to-feet conversion constant of 3.2808, obtaining a value of 62.34 feet.

A conversion from metric to linear length results in a very simple equation than can be used to determine the length of the quarter-wavelength segment of a dipole:

$$\text{Length in Feet} = 234/f(\text{mHz})$$

A hand calculator is an aid if you wish to make your own antenna calculations.

Dipole Dimension Charts. Quarter-wave segment lengths for each of the Amateur bands, 10 through 160 Meters, are given in Table 1. For example, each quarter-wave segment of a dipole antenna cut to to 14.2 MHz in the 20-Meter band should have a length of 16.48 feet. Table 4 gives dimensions for dipole quarter-

Table 1—Here are the dimensions for cutting half-wave dipoles for the various Amateur frequencies below 30 MHz. The number given represents one-half the total antenna length.

FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
160 METERS	
1.81	129.28
1.83	127.86
1.85	126.49
1.87	125.13
1.89	123.80
1.91	122.51
1.93	121.24
1.95	120.00
1.97	118.78
1.99	117.59
80 METERS	
3.525	66.38
3.550	65.92
3.575	65.45
3.600	65.00
3.625	64.55
3.650	64.11
3.675	63.67
3.700	63.24
3.725	62.82
3.750	62.40
3.775	61.99
3.800	61.58
3.825	61.18
3.850	60.78
3.875	60.39
3.900	60.00
3.925	59.62
3.950	59.24
3.975	58.87
40 METERS	
7.025	33.31
7.050	33.19
7.075	33.07
7.100	32.96
7.125	32.84
7.150	32.73
7.175	32.61
7.200	32.50
7.225	32.39
7.250	32.28
7.275	32.17
20 METERS	
14.025	16.69
14.050	16.66
14.075	16.63
14.100	16.60
14.125	16.57
14.150	16.54
14.175	16.51
14.200	16.48
14.225	16.45
14.250	16.42
14.275	16.39
14.300	16.36
14.325	16.33
15 METERS	
21.05	11.12
21.10	11.09
21.15	11.06
21.20	11.04
21.25	11.01
21.30	11.98
21.35	10.96
21.40	10.94
10 METERS	
28.2	8.30
28.4	8.24
28.6	8.18
28.8	8.13
29.0	8.07
29.2	8.01
29.4	7.96
29.6	7.91

wave segments for reception on the various shortwave broadcast bands. Dipole lengths for the various WWV frequencies are given in Table 3.

Lengths are given to a decimal part of one foot in the tables. In addition, Table 2 permits you to make an approximation in inches. In fact, when erecting an antenna for use with a transmitter, there are other variables, such as proximity to ground and metallic surfaces, as well as antenna element diameter that influence the exact resonant frequency. Therefore, cutting an antenna within an inch or two of indicated value is satisfactory. For example, in cutting the dipole for 14.2 MHz use, a practical value is 16-feet, 6-inches. Note from Table 2 that the six-inch figure is appropriate for a decimal part falling between 0.55 and 0.65.

It has been my experience in cutting antennas, that it is preferable to cut elements somewhat on the long side, permitting you to trim down the antenna to a specific resonant frequency after initial tests have ben made. Of course, antennas for receive-only use are not nearly so critical as to their length. Consequently, in Table 4, one dimension is given for operation over the specific shortwave broadcast band.

Of course, it should be stressed that an inch or two of length has a much more decided effect on the resonant frequency on a higher frequency Amateur band as compared to a lower one. Thus, you should be more careful in cutting the dipole for 10 or 15 Meters, as compared to the cut for 80 or 160 Meters. For example, a differential of 3-inches on 10 Meters might result in a frequency change of approximately 1 megaHertz, while a similar differential on 80 Meters corresponds to a frequency shift of only 20-25 kilohertz.

Dipole Directivity. The horizontal dipole is directional. As a transmitting antenna, it sends out

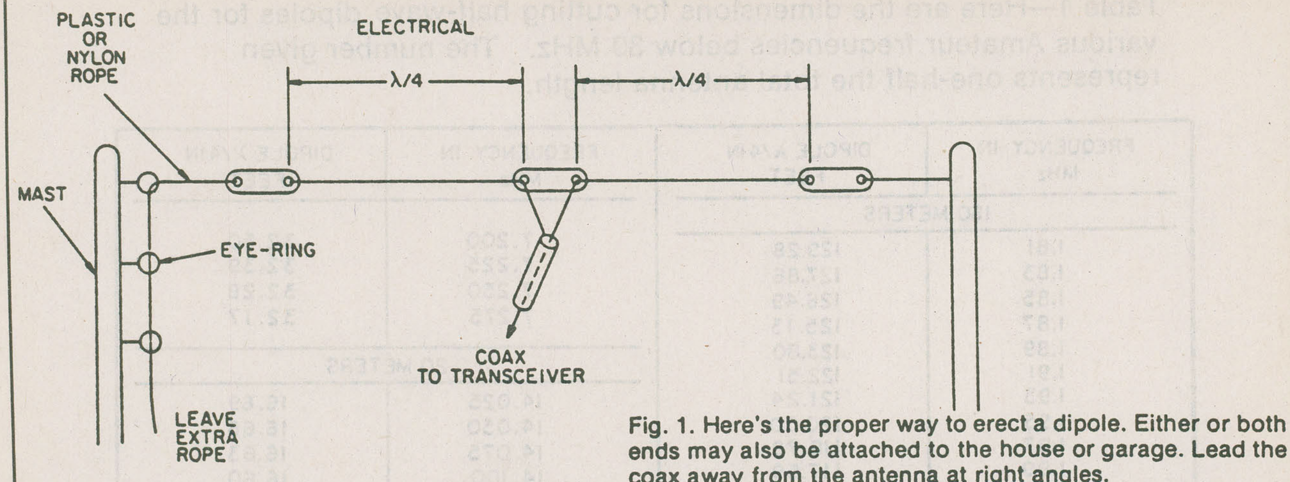


Fig. 1. Here's the proper way to erect a dipole. Either or both ends may also be attached to the house or garage. Lead the coax away from the antenna at right angles.

maximum radio energy (radiation) in the two directions broadside (perpendicular) to the antenna wires (Fig.2). As a receiving antenna, it displays maximum sensitivity to radio signals arriving from the same two directions. Radiation and sensitivity taper off at angles away from the perpendicular, declining to a minimum in the direction along the line (parallel) of the antenna wire. The response pattern of Fig. 2 is a theoretical one. The antenna does radiate energy at other angles and is sensitive to incoming signals as well. The extent of the differential depends upon a number of variables including type of antenna, proximity of ground, nearby metallic structures, propagation conditions, transmission line system, etc. It is a fact though, that maximum radiation and sensitivity occur perpendicular to the antenna wire and minimum in the direction of the antenna wire. The figure-eight pattern is itself rather broad, and it is only at angels near to the angle of the antenna wire that the response is sharply down.

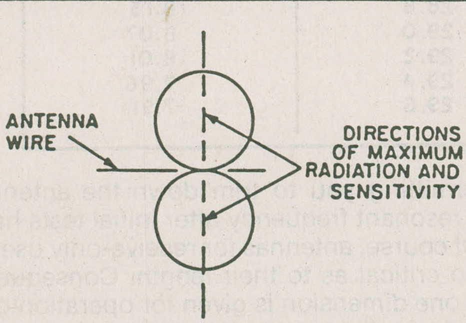


Fig. 2. If you're interested in working a particular area with yur dipole, then be sure to orient it properly. The maximum amount of RF is radiated perpendicular to the line of the antenna wire itself.

In practice then, it is a good idea, if possible, to erect the dipole antenna with an orientation that places it broadside to the direction toward which you wish to radiate maximum signal or display maximum sensitivity. If your intent is to minimize the pickup of an interfering signal, you should point the dipole antenna wire in that direction.

DECIMAL PART OF ONE FOOT	INCHES (APPROXIMATE)
0-.05	0
.05-.10	1
.10-.15	2
.15-.25	3
.25-.35	4
.35-.45	5
.45-.55	6
.55-.65	7
.65-.75	8
.75-.85	9
.85-.90	10
.90-.95	11
.95-1.0	12

Table 2—Use this table to convert the decimal portion of the feet measurement given in Table 1, to inches. Always cut your antenna a bit longer at first. It's easier to trim it down than to add length later.

Dipole Antenna Components. Essential components of the dipole antenna are: antenna wire, dipole center connector, end insulators, support rope, transmission line, and other accessories as needed.

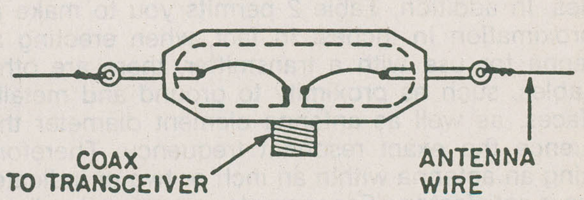


Fig. 3. The best method for mating the antenna to the transmission line is a coax-to-dipole insulator/connector.

Table 3—For receive-only operation, the dipole is still a very good choice. Here are the optimum lengths for broadband operation. Remember to orient the antenna for the area you wish to listen to specifically.

BAND METERS	FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
120	2.3-2.495	97.5
90	3.2-3.4	70.9
75	3.8-4.0	60.0
60	4.75-5.06	46.8
49	5.95-6.2	38.36
41	7.1-7.3	32.5
31	9.5-9.775	24.4
25	11.7-11.975	19.8
19	15.1-15.45	15.3
16	17.7-17.9	13.15
13	21.45-21.75	10.8

The antenna wire can be the popular 7-strand #22 type, which is common and inexpensive. When it can be found at low cost, our personal preference is for #14 or #16 solid, insulated wire. A good-quality, insulated wire gives you added safety and weather protection. Insulation in no way interferes with the radiation or pick-up of signal.

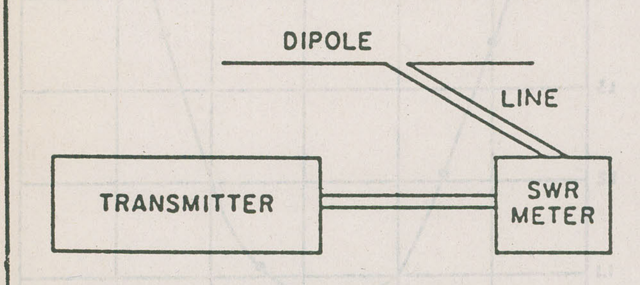


Fig. 4. An SWR meter should be inserted in the transmission line between the transmitter and antenna for accuracy.

Available end insulators are usually made of porcelain and are 1.75 to 3-inches long. They are oval-shaped or rectangular, some having a ribbed construction. Two holes are provided, one for the antenna wire itself and the other for the support line. Support line can be nylon rope or strong plastic clothes-line with a nonmetallic core. To make it easy to lower the antenna, for cleaning or experimentation, the support line at one end can be fed down through eye-bolts to ground level, as shown in Fig. 1.

A coax-to-dipole connector, Fig 3, is the ideal method of linking the dipole antenna to the coaxial transmission line. This connector provides a durable and reasonably weather-proofed connection providing for convenient connection and detachment of transmission line. An alternative plan is to use an end insulator at the center. The two conductors of the transmission line can be attached firmly, soldered and taped to the antenna wire on each side of the center insulator.

There are various support means for horizontal dipole antennas. The variety of TV-antenna hardware such as chimney, side-wall and roof mounts, permit easy attachment to a house or garage. Support itself can be a 5 or 10-foot section of TV mast. Free-standing and guyed mastsare available for ground-mounted supports. A telescoping TV mast is versatile because of its ease of erection and let-down. Guying is required. Guy rings are spaced approximately every 10-feet along such a telescoping mast.

Use good quality coaxial line, either 50-ohm or 70-ohm. Preferred types are RG-58A/U (50 ohms) or RG-59A/U (70 ohms) for low power applications. RG-8A/U is recommended for higher-powered applications, and installations where a long feed line, from antenna to transmitter is necessary.

FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
2.5	93.6
5	46.8
10	23.4
15	15.6
20	11.7
25	9.36

Table 4—Here are the dimensions needed to cut a dipole for WWV time station frequencies. WWV is an excellent source for receiver frequency calibration as well as the correct time. WWV's transmitters can be heard world-wide, 24-hours every day.

Erection of Dipole. Plan your installation according to length, height, and directional orientation. You must consider the space required by the antenna, and where the line must be brought into the house.

Safety and performance are important criteria. For safety reasons, keep the antenna clear of power lines. Be certain that if the antenna falls when erected, or while under erection, it cannot fall across electrical wires. Make certain that under no circumstances, can mast or wire come in contact with power lines if you lose control of the mast or antenna. Keeping clear of power lines also improves the antenna performance. You will pick up less power lines noise on receive. On transmit, you will radiate the least signal into the power

lines, minimizing loss and possible interference with home entertainment units such as television receivers and high-fidelity amplifiers.

Orient the antenna to best meet your needs. If you wish to radiate maximum signal east and west, orient the antenna wire north and south. In a built-up area, it is not always possible to find an ideal mounting situation. However, within reason, it is not necessary that the two antenna ends be the same exact height above ground. Neither must the two quarter-wave segments of the dipole be in an exact line. Stay as close as you can to the idealized situation, but don't worry if you must make limited departures. The antenna will still perform well if you are reasonable in the changes you make.

f(mHz)	SWR
7.005	1.65:1
7.025	1.5:1
7.050	1.35:1
7.075	1.21:1
7.100	1.1:1
7.125	1.08:1
7.150	1.08:1
7.175	1.11:1
7.200	1.2:1
7.225	1.36:1
7.250	1.51:1
7.275	1.75:1
7.295	2.2:1

Table 5—Measuring SWR vs. frequency and plotting the results will help you determine the exact resonant frequency by converting these plot points into a sample graph as in Fig. 5.

Receive Only. The same general considerations must be made in the erection a receive-only antenna, with the exception that power handing capability and transmitter matching are no longer factors of concern. Thus the antenna need not be cut as precisely. The two-wire transmission line can be made of lamp cord or, preferably, a good quality 300-ohm TV ribbon line. A combination of dipole antenna and TV line makes a good combination for short-wave listening on the international broadcast and radio amateur bands. A receiving dipole cut for 35-feet on each segment is a reasonable antenna for all-band listening. However, if you want peak performance on some particular band. Orient this antenna with its figure-eight reaching out in the favored direction.

Tuning With An SWR Meter. An SWR meter connected between transmitter and transmission line, Fig.4, can be used to measure the resonant frequency of a dipole. To go a step further, the antenna can now be trimmed or extended if it does not resonate to the desired frequency. The results can be observed by the SWR Meter, as the antenna resonant frequency is moved up or down the band. Since it is easier to trim off rather than to add on wire length, cut the initial antenna wire longer than the specified value for the particular frequency, in order to catch up with any variables that might influence resonance. A practical example will demonstrate an acceptable procedure.

Assume an antenna is to be cut for 7150 kHz in the 40 Meter amateur band. Table 1 indicates a dipole length of 32.73 feet. This suggests a dipole length of 32-feet, 9 inches. Cut each dipole element to 33-feet, which would be for a resonant frequency of 7100 kHz. Erect the antenna on a temporary basis.

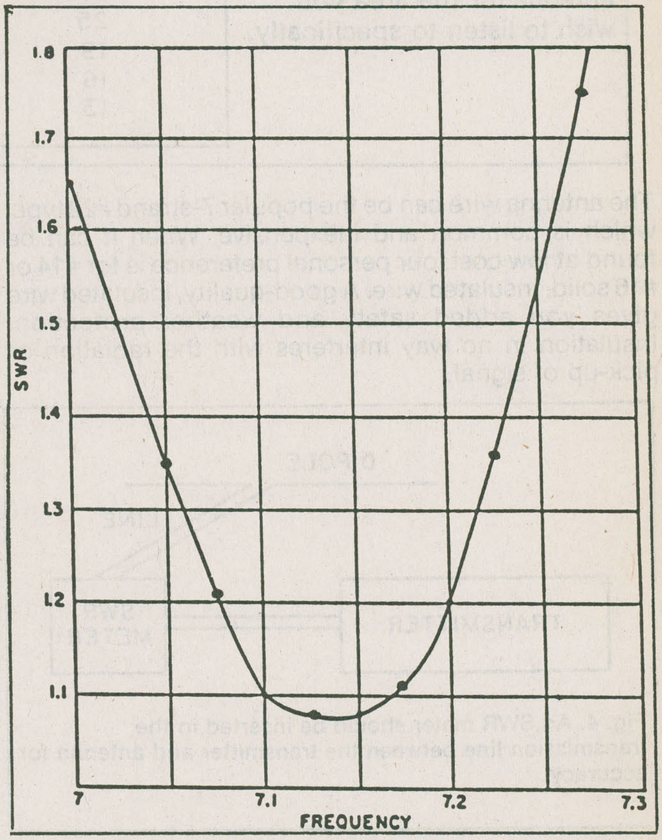


Fig. 5. Plotting the points recorded in Table 5 of measurements made of our experimental dipole for 40 meters pinpoints the antenna's resonant frequency. Even though the curve is rather steep, we manage to achieve an SWR under 2.0:1 for just about the entire band.

Measure the SWR every 25 kHz between 7025 and 7225. Set the readings down in a table form of frequency vs. SWR. Determine the precise frequency at which the SWR reading is minimum. This would be the resonant frequency of the dipole. In our example, it was exactly 7050 kHz.

Inasmuch as the resonant frequency reading is low, you can now trim the antenna to attain the desired resonance. Be careful not to trim off too much. According to Table 1, each trimmed inch corresponds to a frequency change of approximately 20-25 kHz. In our example, we trimmed off six-inches, and increased the resonant frequency to 7141 kHz. If your SWR reading is low, and the resonant indication falls near to 7150, let well enough alone.

The plot of our experimental antenna is shown in Fig. 5. Note that even at the band edges, the SWR reading is

Horizontal Dipole Antenna

reasonable. In the range between 7050 and 7250 kiloHertz, the SWR meter indicated almost ideal performance.

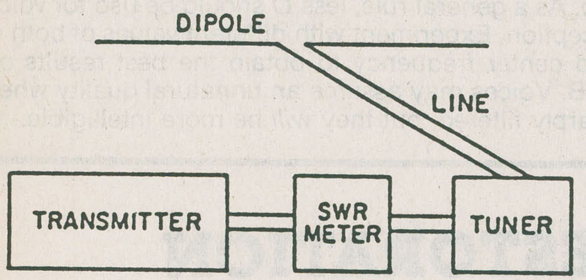


Fig. 6. The antenna tuner allows the transmitter to work into an optimum load even if the dipole itself is not cut for the correct frequency. A tuner won't correct an inefficient antenna installation.

Antenna Tuners at Work. The primary function of an antenna tuner, Fig. 6, is to provide a proper match between your antenna system and transmitter. In so doing, your transmitter sees a proper load and is able to operate at the optimum conditions of its design. The tuner does not alter the performance of the antenna or the SWR on its transmission line. Rather, it makes certain that an improper SWR does not result in unfavorable operation or possible damage to your transmitter. Primarily it is a transmitter protector.

However, a tuner has a number of secondary benefits that enhance antenna system experimentation and permits the use of the antenna systems that are not, in themselves, ideal for matching the standardized 50-ohm output of modern ham radio equipment. Again, it must be stressed that the tuner does not influence the performance of an antenna system. Rather, it acts as an interface between an antenna system and transmitter.

An additional secondary benefit is that it reduces harmonic and spurious signal radiation because it blocks the path between any such signals generated by your transmitter, and the radiating antenna. The tuner also rejects incoming signals that are on frequencies removed from the desired operating band. In effect, it reduces the sensitivity of the receiving system to image and other spurious frequency components.

A tuner makes the dimensioning of a horizontal dipole antenna less critical. It extends the frequency range of operation of the antenna that will provide an ideal match to be transmitter. For example, an 80-Meter dipole cut to 3750 kHz will be made operable over the entire 80 Meter band from 3500-4000 kHz. The electrical performance of the antenna will not differ greatly from an antenna cut precisely to some specific frequency on the band. Even though the SWR on the transmission line be rather high at the band extremes, the transmitter itself will look into an optimum load.

Conclusion. The horizontal dipole is indeed a versatile antenna, giving good performance at low cost. It should be dimensioned properly, and should be used with an SWR meter to evaluate its performance. A tuner insures proper match between dipole antenna system and transmitter, and also extends the operating bandwidth of the dipole in terms of proper matching to the transmitter. Let the dipole start you off in your first experimental activities with antenna systems. ■

THE FUNDAMENTALS & FLEXIBILITY OF INTEGRATED CIRCUITS

input of the first NAND gate goes high and the output of this gate and the input of the following gate goes low. The output of the second NAND gate goes high and the LED goes out. When the switch is opened the capacitor discharges through the first gate and R1. After the voltage on pin 12 of the first gate is low enough the output of the first gate goes high and the output of the second gate goes low and the LED comes back on. Try different sized capacitors for C1 and different sized resistors for R1 and see how long the LED stays off.

FREQUENCY DIVIDER

The Frequency divider (fig. 6) is often used in digital logic circuits. For example, in digital clocks, frequency counters, digital VOMs and many others. This frequency divider is a divide-by-two circuit. Follow the schematic carefully. If everything is connected correctly, the LEDs should blink on and off. Note that one LED will blink twice as fast as the other LED.

OSCILLATOR/AMPLIFIER

This is a very low frequency oscillator. (fig. 7) The LED is connected in series with a 330 ohm resistor between the output of gate number 2 and pin 14. Gate number 2 is used as a buffer. A buffer is a circuit that helps to isolate one stage from another. In this circuit, gate number 2 not only "buffers" the output of gate number 4 from its load (LED), it also increases the signal strength, so it also acts as an amplifier.

Please keep in mind that the SN7400 has a lot more uses than those shown in these demonstration projects. Don't be afraid to experiment with other circuit arrangements. Just remember not to exceed 5 volts VCC. And above all, enjoy yourself. ■

SELECTIVE AUDIO FILTER

not let the source overload the receiver; weak signals are preferable. Adjust the receiver's fine-tuning to maximize S-meter response.

Now, turn on on your filter. Feed the signal from your receiver's headphone jack to the filter's input (J1), and plug a low-impedance headset into J2. With R3 set for maximum *Q*, adjust R7 for peak headphone volume.

Disconnect the RF source from your receiver, and set R3 for minimum *Q*. Now hunt for CW signals on the ham bands. When you encounter a signal plagued by QRM (interference), tune it in as best you can with receiver's fine-tuning control. Then boost the *Q* with R3 to cut out the interference.

A Final Note

Although this filter was originally intended for CW operation, it was found to enhance SSB reception, too. As a general rule, less *Q* should be usd for voice reception. Experiment with different values of both *Q* and center frequency to obtain the best results on SSB. Voices may assume an unnatural quality when sharply filtered, but they *will* be more intelligible. ■

BASIC TUBE RESTORATION

you hobby knife. Leave some of the glue that is still bonded to the base. It can be used to anchor the new epoxy, ensuring a tight connection. Next, mix some fresh epoxy and apply it to the base and the bulb. Now you can guide the labeled wires into their corresponding pins. Seat the bulb in the base properly and solder the wires to the pins. This procedure should be done while the epoxy is still wet so the hot air from the heated pins can expand. After the epoxy has dried, the base should have a tight fit on the bulb.

Joining Broken Wires

Another problem often associated with a loose base is broken wires. These are also relatively easy to repair. However, you must take care or you will destroy the tube. Tin the wires and join them, or use a jumper if they are too short. When you do this on a tube, be careful not to heat the wire too long or the glass-metal seals will develop leaks. Also, be very careful with old wires. They are often brittle and will break under very little stress. Once you have made a good connection, the rest of the tube can be reassembled.

Conclusion

So, you see, simple restoration of old electron tubes is really not that difficult if you are careful and take a little time. The materials are inexpensive and can be found in most home workshops. Hopefully, the procedures that we have described can revive some of your old tubes and make them a useful part of your antique radio restoration. ■

TRASH CAN SPEAKER SYSTEM

Our speaker systems are now almost complete, however, one more step remains, which demonstrates how sometimes science merges into art. Look at the accompanying diagram. Notice that the speakers sit slightly off the floor, on wood blocks. This is not for cosmetic reasons. What we have constructed here is a bass-reflex speaker system. That little bit of space between the floor and the bottom of the speaker enclosure (the top rim of the trash can) is a tuned-port, although we have not tuned it yet. Cut varying thicknesses of wood blocks to set the speakers on. Three blocks per speaker should be sufficient. Now, hook up the two speakers to your amp and put on program material that has good strong bass. Pipe organ or string bass is best. Electric bass guitar is not as good because the bass really doesn't go down as low. Using blocks of different thicknesses (¼" to ¾") play the music over and over and notice which thickness of the block makes the bass sound loudest. When the bass seems loudest, the port is optimally tuned.

As an additional improvement, you might try stuffing the enclosure full of fiberglass sheet insulation. The kind used in attics, without the aluminum foil backing. Hold it in place with vinyl electrical tape. This will have the effect of smoothing the response and should eliminate any stray vibrations you may be getting. Or you may decide that you like the less-smooth response better and leave it out. Let your ears be your guide.

THE HANDBOOK ELECTROLAW

If you can begin at start and go all the way to finish, you will have covered **all** of "Ohms Law", one of the most important principles of electronics. It is the mathematical relationship between voltage, current, resistance, and power. (E, I, R and P respectively). If you are good at transposing simple algebra, it will help. If not, try it anyway and you will still learn something. Good luck! The basic formulas are $E = IR$ and $P = IE$.

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